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Entomology in Relation to Conservation

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Several factors, including the economic stress under which agriculture has been laboring during the last few years, the severe dust storms, the frequency of devastating floods, the ever increasing losses of soil through water erosion, the continued depletion of our forest resources and the diminution of wildlife, have combined to focus attention on conservation.

With the large-scale work in the field of conservation being undertaken by various governmental agencies and the active interest of many individuals and organizations, it appears not only desirable but necessary for entomologists to study the situation and make their full contribution to the building of a sound and enduring conservation program.

Insects have demonstrated repeatedly that they must be reckoned with in almost every field of human activity. Any large-scale changes in land use are certain to affect insect populations and insect depredations. There is abundant evidence that the rapid clearing of forests and breaking of prairies for agricultural purposes following the pioneering period in this country led to increased destruction of the cultivated crops by insects. It is difficult to predict with accuracy what may be the effects of the reverse process on insect problems, that is, the removal of marginal land from agricultural production.

It seems reasonable to believe that with some pests the situation may be improved, while with others it may be made worse. The situation is most likely to be worse during the period of transition. The whole question of the interrelation of man, insects, cultivated plants, wild plants, and wild birds and animals is most intricate, and its solution demands the closest application and the exercise of the best judgment of research workers in many fields, as well as the complete cooperation of numerous governmental agencies, farmers, lumbermen, sportsmen and many other groups constituting our present day society.

In order to encourage this cooperation, and to find ways and means by which the science of entomology may be of greatest assistance in meeting present day conservation problems, a committee on the relation of entomology to conservation has been appointed, and I trust that the association will be disposed to approve this action by continuing this committee.

Entomology as a Conserving Science.—Entomology is one of the major contributors to the field of conservation. As a matter of fact, the objectives of this science of ours are wholly in the direction of conservation. By the effective application of entomological knowledge, human life and health are conserved, and protection is lent to livestock, forests, crops and the many other possessions and interests of man, thus clearly giving entomology rank as one of our most far-reaching and important conservation agencies.

Many are prone to think of conservation in a restricted sense, for the most part limiting it to protection of things existing in their natural state. I would have you think of it as relating to the husbanding of all things directly or indirectly of value or interest to man.

Naturally the conservation of those resources and commodities which are of immediate practical value to man command most attention, and entomology has contributed in large degree to the protection of these vital necessities of life.

INSECTS AND HEALTH.—In the conservation of human lives, entomology takes a position at the forefront in importance. As is well known, the mosquito-borne disease, yellow fever, levied a terrible toll of human lives in the western hemisphere for years before the relation of the mosquito to the disease was discovered and methods of control were developed. Malaria, that dread decimator of peoples throughout the tropical and temperate countries of the world, that moulder of the destinies of nations, still, half a century after Ross's discovery of the insect-disease relationship, remains a major problem in conservation of human lives.

Another disease of man, bubonic plague, which history shows us has swept away millions of lives, has been stripped of its terror and largely brought under control since the determination of the role of rats and fleas in its causation. Without knowledge of the relationship of insects to these and many other human diseases and of methods of controlling them, the world would be in a sad plight.

It is difficult to estimate the value of conserving human energies through the protection of man from insect attack. Certainly, efficiency of labor and total production are greatly increased, and the happiness and general tone of society are enhanced by reducing severe insect annoyance. The shortening of work hours, and other modern developments provide more leisure and make necessary more and better recreational opportunities. If recreational areas are to be fully and satisfactorily utilized, insects which carry disease, annoy man or deface recreational areas must be controlled.

INSECTS AND NATURAL RESOURCES.—Attention is now directed to some of the problems involving the relation of insects and insect control practices to wind and water erosion, water conservation, soil building, and forest and wildlife conservation.

Owing to his eagerness to acquire wealth quickly and his ignorance of the fundamental principles of sound agriculture, man has made many grave mistakes, which if not speedily and intelligently corrected may bring untold woe to future generations.

It has been stated that almost 40 per cent of the farm lands abandoned in the United States were abandoned as the direct result of soil erosion. We now witness forests slashed and burned without adequate provision for their replenishment, floods occurring with increasing frequency and destructiveness, tremendous areas in once fertile sections of the country so gullied by waters as to be useless for agriculture, silt filled streams, almost devoid of fish life, carrying our fertile top soils to the sea, soil impoverishment manifest in many formerly productive areas, wildlife resources depleted to an alarming degree and thousands of square miles of land rendered almost uninhabitable by the blowing away of the surface soil. Obviously vigorous corrective action is necessary, and such action is now being taken by various governmental agencies. In this corrective work numerous entomological problems are being encountered, and a full participation by entomologists in this work as it progresses may avoid some insect problems and solve others with a minimum of expenditure for research and a maximum saving of crops and resources.

INSECTS AND EROSION.—As is well known, there is a close relationship between soil cover and erosion by wind and water. Although man is principally responsible for the destruction of cover, insects probably play a much more important part in this than is generally supposed or known. Literally millions of insects, such as ants, caterpillars, beetles, and grasshoppers, are engaged in devouring grasses, weeds, shrubs and forests. When certain species appear in outbreak proportions, the destruction of cover becomes serious. White grubs have been known to be so numerous as to cut loose great sheets of sod, which were lifted and carried away by wind or water.

The part played by grasshoppers in the removal of soil cover is of first rank. In severe outbreaks not only is every green leaf removed, but many of the stems, crowns and dead protective vegetation as well. Even in the face of droughts or other unfavorable growing conditions the vegetation would usually develop sufficiently to form a reasonably satisfactory cover if grasshoppers were not present. Hundreds of thousands of acres of land in Nebraska, Wyoming, Montana and the Dakotas were stripped of vegetation by grasshoppers during the last few years,

permitting the soil to be severely blown and clouds of dust to be formed.

This condition is often attributed to the drought and to overgrazing by livestock. The part which grasshoppers play in this denudation has been demonstrated in a striking manner by experiments conducted by J. R. Parker in Montana in 1936. Screen cages were placed over grazing land to exclude the grasshopper and similar areas were fenced to exclude livestock. At the end of the season the fenced areas were practically devoid of grass, whereas those protected from the grasshoppers were well covered.

INSECTS AND FORESTS.—It has been shown that in a dense hardwood forest only one-half of the rainfall reaches the ground. Therefore, the defoliation of extensive forest areas by insects such as the pandora moth, the hemlock looper, the spruce budworm and the gypsy moth may have some direct influence on soil erosion and floods. What is more important is the destruction of timber by these insects and especially by bark beetles. This sets the stage for consuming forest fires, and as a result we have floods and soil erosion in sequence.

The seriousness of insect problems in the propagation of trees in forest nurseries is well known. In fact, insects are among the important limiting factors in producing the millions of young trees needed in the present extensive reforestation work. Entomological knowledge is inadequate to meet this situation, and extensive research is necessary to develop more effective and practical methods of preventing these losses.

The black locust has been extensively planted in recent years for the purpose of checking erosion and for providing supplies of firewood and posts. The locust borer has made it impossible to secure satisfactory stands in many parts of the country, particularly on the poorer soils. F. C. Craighead has pointed out that the vigor of the individual tree is the most important factor influencing borer damage. The desire to grow locust trees on the poorest types of soil presents the entomologist with a most difficult problem. If a method of meeting it through coppice, the development of borer-resistant strains or other means, is not forthcoming, recommendations regarding the planting of this tree for the purposes previously stated may require modification, and the hope of making its growth profitable through the production of posts will have to be abandoned in some areas.

The relation of insects to seed production and reseeding of forest, agricultural, and range areas appears to have received little attention, yet under certain conditions insects may be a factor of importance in this vital phenomenon. In this connection the part which bees and other pollinizing insects play in assisting in the production of fruit should be considered, as well as the insects which retard or prevent it.

INSECTS AND GRAZING LAND.—One of the leading factors contributing to destructive wind and water erosion on the range lands of the West is overgrazing. In the correction of the serious conditions which have resulted from this ill advised practice, it would appear advisable to give attention to insects and the important part they must play in the complicated ecology of the range. There may be a possibility of hastening the restoration of the original desirable flora by insect control. In range improvement work in the Southwest, removal or thinning of undesirable or dense plant growths, such as those of cactus and cedar, is being practiced. Such work has a beneficial effect on livestock by reducing the incidence of sore mouths from eating cactus, thus lessening opportunities for screwworm infestation. It also makes the finding of infested animals an easier task.

One of the most serious insect problems of the West, that of the control of the beet leafhopper on sugar beet, has been intensified by misuses of the land, *viz.*, overgrazing and intermittent farming. This insect, as you know, transmits curly top disease of beets, tomatoes and other crops. Heavy losses from curly top are associated with the occurrence of high populations of the beet leafhopper. These high populations are produced as a result of the availability to the insects of extensive areas of summer weeds, such as Russian thistle, bract scale and fogweed, growing on intermittently farmed lands, and of winter weeds, especially plantain, peppergrass and mustard, which appear on vast overgrazed areas.

As has been pointed out recently by R. L. Piemeisel and F. R. Lawson, as a result of extensive ecological studies,

"The correction of the two uneconomical practices, intermittent farming and destructive grazing, is in accord with the general principles of land conservation. Such a correction would result in greatly reducing leafhopper populations and the curly top damage to crops."

Under drought conditions in the Southwest, termites sometimes play an important part in encouraging erosion. For instance, in southern Texas during the years 1916–18 the activity of myriads of these insects did much to destroy plant life and facilitate the soil movement by covering the plants with their earthen tunnels.

It is likely that certain insect problems will be intensified by the withdrawal of unprofitable lands from agricultural production. The build-up of destructive insects in these areas should be watched, especially during the period of transition from cultivated crops to native grasses, trees and other more permanent vegetation. Propagation of such insects as grasshoppers, beet leafhoppers and cotton leafhoppers is likely to take place on weeds coming in on such areas, and hibernation conditions favorable to many destructive insects may be provided.

INSECTS AND CLEAN-CULTURE FARMING.—Clean-culture farming under crops such as corn, cotton and tobacco is conducive to tremendous soil losses from wind and water. This is particularly true in sloping fields. H. H. Bennett, Chief of the Soil Conservation Service, has stated that a 2½-inch rain which fell on July 1, 1933, washed 39 tons of soil per acre from a cornfield near LaCrosse, Wisconsin, and that 27 per cent of the rain was lost as run-off. On an adjacent piece of land of the same kind and slope but covered with bluegrass, not a drop of water or a particle of soil was lost.

One of the suggestions of the soil specialists to meet this obviously serious condition is the employment of strip planting. The principles of strip planting are by no means new, for they have been widely practiced for many years in older countries of the world. In general, insect depredations are less severe in these old countries than in our own. The planting of extensive acreages to one crop has led, in the past to serious insect losses. There is, therefore, some practical as well as theoretical ground for the argument that strip planting may be helpful in combating insects. It is logical to suppose that the spread of a deleterious insect which becomes established locally is less hampered in a large field of one crop than in an interrupted planting. There are certainly instances in which natural control of insect pests is favored by strip planting. This results from provision of conditions suitable for the development of alternate hosts of the parasitic or predatory enemies of the crop pest, as recently emphasized by S. Marcovitch. Stimulation of breeding of desirable parasites by such methods appears to be especially applicable to the control of aphids.

We should not, however, generalize too far, for the habits of the insects concerned and the types of crops grown may make a vast difference in the outcome. Certain destructive insects may be favored by strip farming if the crops are not carefully selected and insect relations kept clearly in mind. The practice advocated by some soil conservationists of planting crops in strips, with permanent sod intervening, provides an ideal set-up for the differential and two-striped grasshoppers, which by this plan are enabled to pass directly into the succulent crops as the young hatch from eggs concentrated in the sod strips. The system advocated for use in the dry farming regions of the West of planting grains in strips with intervening strips summer fallowed is especially favorable to the Rocky Mountain grasshopper. The eggs of this species are laid in the unplowed stubble, and from this the young grasshoppers emerge to enter the adjacent crops. The leaving of undisturbed weed-covered summer fallow lands in the North Central states is likely also to increase injury by such insects as Say's stinkbug.

The recommendation of strip planting of alfalfa or clover with peas for erosion control in the Palouse country of Washington and Idaho is giving entomologists considerable concern. This area is especially adapted to the growing of peas, and about 115,000 acres are planted to that crop. The pea aphid may become a serious pest there, and the growing of other legumes in strips through pea fields apparently gives the insect ideal breeding conditions. Strip planting which brings corn and grain into close proximity is likely to intensify chinch bug injury. In

the coastal sections of the Southeast, cotton strip planted with cowpeas often becomes heavily infested with the cowpea aphid. Other instances of such insect-crop relationships will come to your minds.

The more general adoption of the practice of planting well selected cover crops and of interplanting will aid greatly in reducing erosion. As any number of entomological problems may be encountered in this field, there is need for its full consideration from an entomological viewpoint.

Fall plowing in areas where conditions are favorable for erosion is objectionable, but leaving fields unplowed is favorable to such pests as cutworms, bollworms, strawworms and the hessian fly. Here is a place for cooperative effort in developing ways of meeting these problems. Clean culture and the destruction of crop residues are often advocated for insect control. Their importance from this angle is unquestioned, yet such recommendations are frequently counter to others designed to reduce erosion. Sometimes it may resolve itself into taking the lesser of two evils, but often both purposes may be served by an analysis of the situation and a modification of procedure.

WATER CONSERVATION AND INSECTS.—Water conservation practices are for the most part similar to those employed in soil erosion and flood prevention. In addition to the relations referred to between soil erosion practices and insect incidence, a number of other relationships exist between water conservation and insect problems which will be considered later.

There is a tendency for insects of many kinds to become more abundant on crops making a succulent growth in the presence of adequate water. For instance, the contouring of lands for water conservation in western Texas resulted in a decided increase in cotton flea hopper, bollworm and cotton leaf worm damage in certain areas during the summer of 1937. Often, however, the more vigorous plant growth produced may compensate for the damage due to increased insect numbers. When such plant growth tendencies are desirable except for insect damage, the importance of developing and applying insect control measures is at once apparent.

In flood control and water conservation work the impoundment of water with dams is, of course, an essential part of the program. Such impounded waters not only give opportunity for fish and wildlife to breed, but unfortunately also may give rise to mosquito problems. Of these malaria is the most serious. The creation of numerous ponds on farms and ranches to provide supplemental water supplies for livestock, and to reduce run-off, may furnish excellent breeding places for malaria mosquitoes and also favorable conditions for the development of liver flukes and intestinal worms of livestock.

Methods have been developed which are reasonably effective for avoiding or checking mosquito troubles in such areas. These consist principally of clearing timber from the areas to be flooded, especially around the lake margins, removing debris, deepening the water at the lake edges, manipulating water levels, applying such larvicides as oils, pyrethrum extract, or Paris green and introducing top minnows to destroy mosquito larvae. The application of some of these methods is expensive, especially on large projects involving hundreds of miles of shore line.

In areas where malaria is prevalent, and where considerable populations live near the lake margins, such expenditures are necessary and fully justified. The careful planning and continual inspection and supervision of such projects by experienced mosquito fighters with broad biological training is most important. There is much need for additional research in this field with the object of developing cheaper and more effective control measures that are not injurious to fish or wildlife and are applicable to extensive rural projects.

Irrigation, although not a conservation practice, is often a by-product of flood control. Many entomological problems are associated with irrigation and should be considered in planning extensive irrigation projects. The intimate but none-too-well-understood relationship between irrigation and wireworm damage and the prevalence of a number of other crop pests is now generally recognized. Serious mosquito and malaria problems often result from irrigation, and the troublesome eye gnat situation in certain valleys of the Southwest has developed indirectly as a result of this system of agriculture.

INSECTS AND SOIL BUILDING.—J. W. McColloch and Wm. B. Hays state,

"Much has been written on the biology of aquatic situations and plant associations, but the thin layer of soil which supports all plant and animal life is still open for extensive investigation. The problems are unlimited and are of the greatest fundamental importance to the progress of agriculture . . . The reciprocal benefits to the soil through insect activities are numerous but varied and may be classed as soil formation, renovation and maintenance."

The number of living things in the soil is almost beyond our comprehension. It has been estimated that an ounce of soil may contain 30,000,000 microorganisms such as bacteria, algae and fungi. There are also tremendous numbers of animals of one kind or another in soils. A large percentage of these are insects. W. L. McAtee has estimated that there were 1,216,880 animals, principally insects, in an acre of woodland and 13,654,710 in an acre of meadow, based upon an examination of 4 square feet of soil to a depth a bird could scratch. H. W. Morris made a census of the fauna of a permanent pasture in England, which indicated an insect population of 3,586,088 per acre. G. N. Wolcott has made an intensive study of limited areas in Illinois and New York. From his figures the average number of animals per acre is computed at 3,611,124 in the Illinois area and 2,980,810 in the northern New York area. In a tropical forest in Demerara, W. C. Beebe determined the animal population to be 10,640,000 per acre. Who would attempt to maintain for a moment that these vast numbers of creatures do not exert a profound influence on soils with which they are so closely associated, and that the role they play should be more accurately determined and be given appropriate consideration?

One of the pioneers in soil conservation work in this country, N. S. Shaler of the U. S. Geological Survey, in a report published in 1891 took cognizance of insects as soil builders, referring to the parts played by cicadas, beetles, termites, bees, and other insects. Of the dung beetles he says, "A single pair . . . will in one season introduce into the earth several cubic inches of fertilizing material." The work of these beetles was more accurately measured by A. W. Lindquist, who found, in pasture lands in central Kansas, 200 burrows of *Pinotus carolinus* L. per acre, indicating the excavation of 126 pounds of soil, partially from a depth of nearly 2 feet, and the burial of 21 pounds of air dried dung. Many species are concerned in the breaking down of wood, leaves and other plant tissues into leaf mold. Soil is aerated and made pervious to water by burrowing insects. Although the part played by earthworms in soil formation and aeration has received considerable attention, much less consideration has been given to the work of insects.

Termites are recognized as a factor of importance in soil formation, especially in the tropics. J. C. Branner has written that in places in Brazil half the soil surface is covered with termite mounds, some of which contain more than 30 cubic meters of earth.

Ants are so widespread and numerous that they exert a marked influence on soils. Shaler, in the report previously referred to, stated with reference to the "common brown ant": "On a field in Cambridge, Mass., observations made during two summer seasons showed me that the average transfer of soil matter from the depths of the surface of the earth was in the aggregate sufficient to form a layer each year having a thickness of at least one-fifth inch over the area on which the observation was made, which is about four acres in extent." Shaler points out that although ants do not have the peculiar effect on the soil of passing it through the digestive canal, "Nevertheless, because they are much more widespread than their lower kindred, these insects in the aggregate produce a far greater influence on the soil."

INSECTS AND CROP ROTATION.—From the standpoint of soil improvement the value of crop rotation is admitted by all. Likewise crop rotation is often made necessary by insect depredation. Altogether too often, however, insects are not considered in planning a crop sequence, and certainly the statement of H. T. Fernald in 1921 on this subject is still applicable. He wrote in his *Applied Entomology:* "The entire subject of crop rotation is still in a far from settled condition and needs prolonged investigation." In this field, however, the entomologist is in position to offer much aid to those concerned with soil improvement work.

The extensive use of legumes, so vital

to any program of soil improvement, presents certain entomological problems. One of these is the relation of certain soil inhabiting insects to the nitrogen fixing structures of the plants. The nodules are fed upon to such an extent at times as to limit nitrogen fixation. Some of these soil inhabiting insects, such as the bean leaf beetle, have been observed to be most destructive to the root nodules on the poorer soils where soil improvement through the growth of legumes is most needed. Studies carried out by L. T. Leonard and C. F. Turner indicated that the nodule injury is related to the percentage of nitrogen in the roots.

Not infrequently insect damage to crops is most severe where the soil is enriched with barnyard manure. White grubs and the seed-corn maggot are especially concerned in such instances.

The important relations between legume production and the honeybee should not be lost sight of, nor should that of the honeybee and the fertilization of fruit trees and other plants of economic value. The swing from legumes to cash crops during and subsequent to the World War has had a disastrous effect on the soil and has resulted in a marked decline in the number of honeybees in the agricultural West. These intimate relations of bees and cropping practices are interestingly discussed in a recent article by F. B. Paddock. He points out that in order to insure a rapid extension of legume utilization, legume seed must be widely grown and adds: "Such a program of general seed production as a part of land diversification must consider a general distribution of bees." He also observes that the list of trees advocated for erosion control is made up entirely of those which are of value to the bee either for pollen or nectar or both.

ENTOMOLOGY AND WILDLIFE CONSERVATION.—There are many and intricate relations between entomology and wildlife conservation. I can do no more, in this discussion, than to direct attention to some of the more important of these. First, I should like to emphasize the importance of this subject, the dearth of exact information on it and the opportunities at hand for gathering information of scientific and practical value.

At the present time the Federal government is expending approximately $9,800,000 for the establishment of refuges for game protection, for game management studies and in other wildlife conservation work. With the present active public interest in wildlife it would seem that more attention might well be paid to the entomological problems involved.

Relatively nothing has been done to determine the importance of insects and related forms as vectors of diseases or as annoyers of wildlife. There is reason to believe that mosquitoes, ticks and other bloodsucking forms seriously interfere with the health and development of many wild birds and mammals and actually cause the death of no small number. Tularaemia, which apparently decimates bird and animal populations, is freely transmitted in nature by ticks. A leucocytozoön disease which is capable of inflicting heavy losses among wild ducks of all ages is carried by black flies (*Simulium*). This disease may well be responsible for some of the decline in the numbers of wild ducks in recent years. Even such insects as biting lice, which are usually regarded as unimportant parasites of birds, appear to become so numerous at times as to weaken or kill their hosts, and it is likely that the feather damage caused by these pests may interfere with flight, especially in long migrations.

At times, and in certain situations, wild animals may serve as hosts for insects and related forms which are a distinct menace to our livestock industry. For instance, the abundance of deer in restricted areas in Florida and their suitability as hosts of the cattle fever tick has prevented eradication of that tick by the usual methods. When destruction of the deer in these areas was proposed by those in charge of the tick eradication program, certain people interested in wildlife blocked the proposal. Considerable friction has been developed owing to a misunderstanding of the situation and a lack of appreciation of the larger economic factors involved, thus demonstrating the need of the widest possible viewpoint in order that the relative importance of the various factors involved in such cases may be correctly determined.

H. L. Stoddard has shown that in southern Georgia the fire ant, *Solenopsis geminata* (F.), may destroy as many as

15.4 per cent of the young quail as they hatch. Often a high percentage of the young of certain song and insectivorous birds are destroyed by the larvae of the parasitic flies of the genus *Protocalliphora*.

Some insects have an important indirect adverse effect on wildlife by their destruction of protective cover and food. Seed infesting species in particular may limit the distribution and usefulness of certain species of plants as food for wildlife. Some of these difficulties and the danger of increasing insect problems on adjacent cultivated crops may be avoided by giving the insect factor consideration in making plantings for wildlife. In severe grasshopper outbreaks the destruction of grain, corn, grasses and the fruit of trees, shrubs and weeds leaves upland game with little of its customary food, while hiding places and natural protection are largely wiped out.

Insects also play an important useful role in connection with wildlife. They not only constitute the principal food of certain species of birds, but they serve as emergency rations for many other species and as the staple diet of many kinds of fish. Furthermore, berries and seeds are made available for food for wildlife by the pollination action of bees and other insects.

In this connection it should be pointed out that certain species of trees or shrubs may be desirable as food for birds or animals but be so subject to attack by insects or play so important a role as intermediate hosts for plant diseases as to make objectionable their presence in given areas. One thinks of the chokecherry, which greatly favors tent caterpillars, and the barberry, which because of the part it plays in grain rust propagation, is outlawed in the grain belt.

More investigational work on the interrelations of fishes and insects should yield results of value to both conservationists and entomologists. This might well include studies of the effect of eroded materials, increased water temperatures and sunlight due to lumbering operations, and stream contamination by sewage and industrial wastes on insects utilized as food by fish.

It is likely that the destructive effect of stream pollution on aquatic insect and plant life is as important as its direct effect on the fish. The ability of deleterious insects to live under conditions unfavorable to useful forms is demonstrated by mosquitoes, which breed in untold numbers in highly polluted waters.

ENTOMOLOGY AND FOREST CONSERVATION.—Reference has already been made to the great damage to forests inflicted by insects, and to some of the ways in which forest insects are related to erosion and flood problems.

In certain instances the modification of silvicultural practices and the employment of control methods have doubtless resulted in the prevention of devastating insect outbreaks. However, altogether too little is known about many forest insects to meet fully the existing forest situation.

Time will not permit adequate discussion of this subject here, but it may be well to point out a few additional illustrations of the relation between forest management and insect control, and the importance of some insect problems in connection with forest improvement and utilization.

The spruce budworm is an important factor in the production of spruce and fir pulpwood in New England. The maintenance of a vigorous growth and the reduction of the percentage of fir will practically eliminate this injury. Losses from the white-pine weevil can be materially reduced by planting white pines only on the more favorable areas and spacing the trees not more than 6 feet apart.

Changes in practices formerly employed in the naval stores industry have increased the yield of gum, greatly prolonged the period of turpentining operations on a given area, and at the same time reduced injury from the turpentine borer, which has been responsible for heavy losses from windthrow.

The host preference of insects often may be taken advantage of in combating forest insects and must be considered in forest development and improvement. Pure stands of species of trees susceptible to attack by serious insect pests offer an opportunity for widespread devastation. However, insects are often favored by the presence of mixed stands, as is well demonstrated in the case of the gypsy moth.

S. A. Graham has pointed out recently that in parts of Michigan a walking stick at times kills more than half of the black oaks in an infested area, but that white oaks, red maple, aspen and conifers are

not injured. Converting the forests by planting white oak and conifers under the black oaks is the most nearly permanent and least expensive method of controlling the insect and will result ultimately in the improvement of the forest. Thus in many instances forest management must be depended upon very largely to meet insect problems.

INSECT CONTROL AND CONSERVATION.—Brief reference has already been made to the tremendous tax levied by insects. Naturally such degree of control as is effected by man is to that extent a conservation force. Control measures have not been developed nor are effective ones applied to an extent approaching what might be desired. However, it is safe to say that hundreds of millions of dollars are saved each year as a result of insect control efforts.

Certain insect control practices now employed are in some degree adverse to the principles of conservation. To keep recommendations in line with these principles, we as entomologists should not be content with the advocacy or the development of a method of insect control that may destroy the pest but disregards many other factors, some of which may be of paramount importance in the long run.

CONTROL OF ORCHARD INSECTS.—It appears that the continued use of heavy applications of arsenicals may be in this class. Health authorities are concerned about the effect on man of arsenic and lead ingested with fruit, vegetables and tobacco that have been heavily coated with insecticides. The devitalizing effects on soils due to the accumulation in them of large amounts of arsenic and lead from orchard spraying are apparently being demonstrated in some of the old orchards of the West. Certain of the light sandy soils of the South also appear to be damaged by the continual heavy poisoning of cotton with calcium arsenate for boll weevil control.

It has been estimated that the top 3 or 4 inches of soil in 18- or 20-year old orchards may carry as much as 2 tons of arsenic per acre. While this may not seriously affect the fruit trees, it is thought by some to be responsible for the difficulty being experienced in growing cover crops so essential to the maintenance of soil fertility. There is much to be learned about this problem but it is too serious to be ignored. The heavy application of lead arsenate to control the Japanese beetle and white grubs in nurseries has also been shown to do serious injury to certain plants grown in the treated soil.

The extreme toxicity to fish of derris, cubé and similar insecticidal materials should not be lost sight of in our insect control operations.

Other insecticidal treatments of soil, as with naphthalene, carbon disulphide and paradichlorobenzene for the control of wireworms or other soil insects, may be very destructive to desirable organisms in the soil. This action and its relation to soil fertility should be studied and the merits and demerits weighed before unreserved recommendations are broadcast. Manure treatment with borax for fly control is another illustration of a practice which should be applied with caution.

CONTROL OF MOSQUITOES.—During the last few years broadsides have been fired by certain sportsmen and wildlife enthusiasts at drainage operations. Mosquito control, or work done under that guise, has received perhaps more than its share of that criticism. The large sums allotted by relief agencies for the control of malaria and other mosquitoes and the expenditure of a considerable portion of these funds on projects which are not supervised by entomologists has precipitated many of the attacks. Anti-mosquito work lends itself well to work relief, and in an effort to find useful employment promptly for large numbers of men, it is not surprising that many projects were undertaken without adequate mosquito surveys or the supervision of trained men.

Proceeding with extensive projects in the absence of these two necessary requisites is certain to result in excessive cost, lowered effectiveness and disturbance of wildlife. This type of work takes us into a complicated ecological problem that demands careful analysis and close supervision by a broadly trained and experienced personnel.

There is no question that changes result from the abolition of mosquito breeding on a given area. The degree of change varies with the type of treatment applied. In populous sections the complete drainage or filling of mosquito breeding places is preferred because of the permanency of such treatment. In less developed areas

open ditching, impounding and the use of temporary treatments such as the application of larvicides may be resorted to. Still farther afield, antimosquito work may be necessary to give protection to communities several miles away, because of the strong migratory tendencies of some of the pestiferous species. It is in these rural districts that the relation of the mosquito control practices to wildlife must receive consideration. The entomologists of the country where serious mosquito problems exist might well give such problems attention. Blame for ill-conceived mosquito control projects and the deleterious effects such work may have on wildlife is likely to be charged to entomologists, even though they may have nothing to do with them.

It may be true that wildlife enthusiasts have frequently exaggerated the ill effects of mosquito control work on wildlife and also the local value of wildlife as compared with that of mosquito control. In some instances, however, those directing mosquito control might well give more attention to ways of accomplishing their objective with least possible disturbance to the feeding and breeding places of wildlife. As a matter of fact, in some areas habitats more favorable for fur-bearing animals and waterfowl may be created in the course of the work.

CONTROL OF FIELD CROP INSECTS.—The charge has been made that game and insectivorous birds and animals have been killed as a result of grasshopper and boll weevil poisoning operations. As far as I have been able to learn, none of the statements along this line has been substantiated. Rather extensive inquiries into this question have been made by F. E. Whitehead in Oklahoma and by W. E. Beed in Iowa, and they could find no clear cases of wildlife destruction from grasshopper poisoning. Doubtless such cases may occur through carelessness or through improper distribution of poison, and the need for proper supervision is emphasized.

Recommendations endorsing the burning of fence rows, woods and crop residues for the control of such insects as the chinch bug, strawberry weevil, pea aphid, boll weevil and mosquitoes have been criticized by wildlife enthusiasts and foresters. Some of this criticism is well founded. It may be said that the burning of grass areas for chinch bug control, the extensive burning of woods for the destruction of hibernating boll weevils or the burning of marshes to facilitate mosquito ditching operations are rarely if ever advocated by entomologists at the present time.

Burning over of woodlands has been common practice in the pine lands of the South for many years. Foresters have condemned this practice vehemently and without qualification until recently, when a few have concluded that controlled burning may have some place. Forest burning even under control may be distinctly deleterious to young trees of certain species, such as slash or loblolly pine, while reseeding or growth of young longleaf pines may be benefited by burning if it is done at the right time and in the right way. The controlled burning of woods may be an aid in combating ticks and chiggers, and in improving range for deer, quail and other game under certain conditions. Entomologists, zoologists, foresters, botanists and soil experts should investigate this relationship more fully, as obviously there is a dearth of information available to guide field practice.

CONCLUSION.—In conclusion, we may say that conservation of our natural resources must go on, and entomologists should do their part in carrying such work to a successful conclusion. It appears that entomologists have not given the consideration they should to this subject, and conservation agencies have in many cases ignored entomological problems. More entomological work and closer cooperation in this field are necessary.

A number of suggestions along this line have come from members of this Association in response to a questionnaire sent out last fall. These include the suggestion that entomologists be employed on the staff of conservation organizations; that State and Federal entomological work in this field be strengthened; that frequent conferences of cooperating agencies be held to map programs and exchange ideas; and that the entomological information along this line be made more generally available. These suggestions are receiving the attention of the recently appointed committee of this Association on the relation of entomology to conservation, and it is hoped that this com-

mittee may be able to bring in some recommendations which, when put into effect, will aid in the solution of the many entomological problems involved and promote conservation in its broadest sense.—1-8-38.

Insects in Relation to Diseases of Truck Crops*

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When I was invited to take part in this symposium I thought that, as I had a general familiarity with the subject, it would be an easy task to state a few pertinent facts regarding the various relationships existing between insects and plant pathogens concerned in the development of diseases of truck crops. It soon became apparent that the task is more difficult than it seemed at first. A greater sense of responsibility grew upon me as I slowly analyzed the large mass of literature dealing with the subject. In the time allotted for discussion, it is indeed difficult to know what to include of fundamental value, and what to exclude from the experimental data presented by various workers and from the vast number of references made to various insects as important agents in the dissemination of plant pathogens or as active factors in the development of plant diseases.

THE VALUE OF THE SYMPOSIUM.—The task before us, admittedly, becomes even greater when we realize that the branch of science this symposium expounds is still in a formative stage. As yet many phases of its border-line interests lie dormant and untouched, and the available information in other phases is subject to radical changes by further research. Though many concepts, trends, deductions and our present knowledge of the field may be susceptible to profound modifications, there is recognized an increasing need in the digestion and coordination of the voluminous literature which is scattered so widely throughout the world, frequently in very inaccessible publications.

The value of this symposium, therefore, is indeed significant as a timely effort to evaluate by critical survey and analysis accumulated material on the subject. It is of value to bring this material in informative presentation to the attention of not only entomologists and plant pathologists, who are primarily interested in the subject, but to call the attention of other biologists, who may be in any way interested in plant or insect life, to these extremely interesting, complicated and challenging biologic phenomena. Another value lies in the hope of bringing closer together the interested workers with the purpose of reorganization of our knowledge for the guidance of future experimental attacks. This will, doubtless, result in important contributions toward solution of the fundamental problems involved.

INSECTS AS VECTORS OF PLANT PATHOGENS.—The relationship between the insects and the entomophilous plants is well known to all biologists. Entomophily is often considered by students of biology as one of the most marvelous phenomena in existence.

Through the ages many striking morphological and evolutionary adaptations have taken place in both insects and plants. These adaptations facilitate cross-pollination and perpetuation of plant species, while insects derive their food, either nectar or pollen. Without this mutually beneficial relation, their existence would now be impossible. In this mutual association the insects cannot be looked upon as promiscuous disseminators of pollen. Specific insects in their successive visitations of flowers of restricted plant species effect pollination by definite placement of pollen grains, incidental as it may be, without which plant species would perish. There are cases of instinctive, almost purposeful pollination of plants by insects, perhaps best exemplified by several species of *Pronuba*, each one pollinating its own species of *Yucca*.

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EXTERNAL STRUCTURE.—The morphological structure of insects, such as profuse pubescence, the presence of spines, branched hairs and special adaptations of mouth parts and legs of the pollen feeders, and the length of the tongue or proboscis of the nectar gathering insects are thought to aid these insects in the process of fertilization of plants.

If pollen grains are living entities, as they are, and certain morphological structures of insects are well adapted for pollen dissemination and actual placement on the stigmatic surface of flowers, then the fungus spores and other plant pathogens, which are also living entities, are indeed comparable to pollen in this respect. While entomophily has been recognized for hundreds of years, the first record of insects disseminating a plant pathogen has been known only for about forty-five years (Waite, 1892). The role insects play in the initiation of plant diseases is not appreciated fully even at present.

INTERNAL STRUCTURE.—In addition to the above mentioned external morphological structures of insects, it is well to add that many internal structures of insects are equally important in the spread of plant pathogens. Digestive systems of certain insects not only passively harbor microorganisms capable of producing plant diseases, but sufficient experimental evidence has been presented by Petri (1910), Rand (1915), Leach *et al.* (1934), Fransen and others that either fungus spores or bacteria establish a delicate food relationship in the insect by living and propagating within the insect's body. Various glands, especially the rectal, anal, intestinal diverticula of many phytophagous insects, as well as the oesophageal bulb of Diptera may be suspiciously looked upon as foci for possible symbiotic relationships between the plant pathogens and insects. Such structures as the minute openings between the anal region of the digestive system and the oviduct of various Diptera make it possible for the eggs to be contaminated with the viable organisms and, upon oviposition in or on plant tissue, may establish important seats of infection. The mouth parts, wings, wax glands and a number of other morphological structures are instrumental in aiding insects in the spread and inoculation of pathogenic microorganisms.

The preferential habits of many insects to feed on decaying vegetables provide ample opportunity for contamination. In some instances, as has been demonstrated by several workers, Huff (1928), Leach (1926) and others, bacteria are essential for the normal development of larvae.

In view of the fact that fungus spores may have minute film of hygroscopic water, and usually, although not always, have a negative electrical charge, while insects have a positive charge, it has been observed that spores have a strong tendency to adhere to the insects' appendages if an insect walks over them and subsequently are quite widely disseminated. This adhering phenomenon can easily be demonstrated in any laboratory.

From these few comparative remarks it is quite evident that insects in addition to playing their role in entomophily are just as, if not even more, effective vectors of plant pathogens.

MODES OF TRANSMISSION.—Although many microorganisms capable of producing plant diseases are well adapted for dissemination by various agencies, such as wind and water, insects constitute one of the very important agencies of not only dissemination, but also of inoculation or actual placement of inoculum in the court of infection. They also serve as powerful agents of ingression, frequently breaking through the various protective devices of plants, such as the epidermis, cutin, periderm, wound cork layer, and others. Under ordinary conditions some of the unbroken protective devices of plants are strikingly effective against the natural penetration of fungi and bacteria. Insects, however, by their powerful mandibles are able to crush through these devices, pave avenues for infection, and often simultaneously may inoculate the freshly made wounds with viable pathogens. Under certain conditions, especially in the presence of oxygen, the wounded plant tissue may soon form several suberized layers of wound cork in an effort to block further invasions of parasites into the healthy tissue. This blocking effect is often met with considerable success. However, by continuous ingress, the larvae of a number of insects, in the process of feeding, break through the corky layer into the healthy areas of the plant, carrying infection with them.

SUMMARY OF MODES OF TRANSMISSION.—Time will not allow the adequate discussion of all of the modes of dissemination and inoculation of pathogens by insects. Some of these will be briefly touched upon in the discussion of specific diseases of truck crops in this paper. It is desirable, however, to give here a summary of various possibilities. While it is true that different types of classification can be made of these possibilities, with the present knowledge of the subject, the following classification seems to cover all known cases:

I. Insects as simple agents of dissemination without themselves wounding the plant tissue. This can be accomplished by the following:
   A. Mechanical dissemination of pathogens by insects without wounding plant tissue. (Many insects may be involved in this type of dissemination.)
   B. Biological dissemination of pathogens by insects without wounding plant tissue. Bacteria, for instance, may be breeding within the insect, and dissemination takes place due to natural movement of the insect. Actual infection may take place by means of contaminated eggs, or feces, placed in the wounds made by other agents, but not necessarily in the wounds made by the spreading agents.
      1. Insect is not obligatory. (Dissemination of potato black leg organism in feces or by the contaminated eggs of *Hylemyia cilicrura* Rond.)
      2. Insect is obligatory. (Dissemination in certain cases of cucumber wilt by means of feces of *Diabrotica vittata* (F.) in the presence of dew or rain water.)

II. Insects as agents of dissemination and inoculation of plant pathogens accompanied by wounding the plant tissue by disseminating agent.
   A. Mechanical dissemination and inoculation of plant pathogens or virus entities into wounds made by the inoculating agent. (Certain mechanically transmitted virus diseases such as cucumber mosaic, spindle tuber of potatoes, yellow dwarf of onions, by aphids; also bacterial wilt of solanaceous plants by biting insects.)
   B. Biological dissemination and inoculation of plant pathogens or virus entities by the wounding agent into the suscept.
      1. Insect agent common, but incidental and not obligatory. (Several virus and bacterial diseases, such as pea virus, certain potato viruses by aphids and bacterial wilt of corn by flea beetles, *Chaetocnema pulicaria* Melsh., *Ch. denticulata* Illiger.)
      2. Insect agent obligatory.
         a. Propagative type of biological dissemination and inoculation of pathogens. Plant pathogens may not only live, but actually propagate within the insect. [Cucurbit wilt by the overwintering specimens of *Diabrotica vittata* (F.).]
         b. Biological type of dissemination and inoculation with so-called "incubation period" within the vector. (Several virus diseases, such as curly top of sugar beets, by *Eutettix tenellus* Bak.; tomato spotted wilt by *Thrips tabaci* Lind.)
         c. Biological dissemination and inoculation with a suggestion of cyclic development of microorganisms within the insects. (Certain phytopathogenic protozoa, such as, *Phytomonas davidi* (Lafont) of Euphorbia and *Stenocephalus agilis* Scop.)

III. Insects as agents of invasion without dissemination of plant pathogens.
   A. Insects are mere wounding agents without producing malformations or physiological disturbances. The pathogens may invade their wounds, establishing infection. (Many biting insects pave avenues especially for bacterial infection.)
   B. Insects are wounding agents with apparent injection of toxic sub-

stances, producing diseases by the toxicogenic insects. (Potato hopperburn produced by feeding of *Empoasca fabae* (Harr.) or Psyllid yellows of potatoes caused by the *Paratrioza cockerelli* Sulc.)

C. Insects are wounding agents, capable of producing profound malformations and abnormal physiological reactions within the hosts, apparently due to mechanical injuries. (Wilting of plants, such as squash caused by *Anasa tristis* De Geer and pseudogalls produced by a number of aphid species.)

After these general considerations of the underlying principles involved in the problems of insects in relation to plant diseases, without discussion of which the entire subject would not be intelligible, we may now proceed briefly with concrete illustrations of some of these relations to truck crop diseases.

INSECTS AND FUNGUS DISEASES.—In spite of the great diversity of morphological structures and adaptations of phytopathogenic fungi for insect dissemination, there are only very few fungus diseases of truck crops known to be initiated by insect activities. Possibly the fungus diseases of vegetables have not received due consideration by the students interested in this field. More fertile illustrations could be cited in the phases of insect relationships to fungus diseases of cereal crops, various fruits and shade trees.

Downy Mildew of Lima Beans.—This is caused by *Phytophthora phaseoli* Thaxter and is known to be mechanically disseminated by the bees at the time of their visits to flowers. Bees, as shown by Sturgis (1898), are considered to be almost solely responsible for the infection of the young ovaries of lima beans, just before the fall of the blossoms. The infection takes place only at the points of floral parts touched by the insect at the time of their visits.

Stigmatomycosis or Yeast Spots of Plants.—Found especially on lima beans, *Phaseolus lunatus*, and cow peas, *Vigna sinensis*, this is another fungus disease that invariably develops in the feeding punctures produced by plant bugs. The green soldier bug, *Acrosternum hilaris* (Say), has a long list of food plants, and disease often develops in its punctures. The constant association of yeast-like fungus, *Nematospora phaseoli* Wingard, with the cited insect suggests possible biological relation between the fungus and the vector, although such relationship has not been established either by Wingard (1925) or Underhill (1934).

Sooty Mold of Vegetables.—This occasionally develops on the plants in the presence of an abundance of honey dew deposited by such insects as aphids, mealy bugs, white flies and others. Sooty mold fungi are dependent upon the honey dew of these insects for nourishment and development. These fungi, if present, may seriously impair the proper growth of plants by interfering with physiological functions such as photosynthesis and respiration.

There are a few other fungus diseases of truck crops in which insects apparently play some role, such as: black leg of cabbage caused by *Phoma lingam* Tode; onion blight, *Peronospora schleideniana* de Bary; late potato blight, *Phytophthora infestans* (Mont.); early blight of tomatoes, *Alternaria solani* (E. & M.); and several other fungi. However, additional experimental work is necessary in order to establish more definite relationship between the suggested insect vectors and these fungi.

INSECTS AND BACTERIAL DISEASES.—Among the bacterial diseases of plants we find several very destructive to truck crops. Numerous contributions by several workers such as Smith (1911), Rand & Enlows (1916), Leach (1926) and others supply experimental proof that insects are very important factors in the spread of bacterial plant pathogens. Their role in the epiphytotics of bacterial diseases is not restricted to dissemination and inoculation of bacteria. There is evidence to show that at least certain bacterial plant pathogens multiply within the insects, and in some cases insect vectors are sole agents of primary and secondary infection.

Bacterial Wilt of Cucurbits.—Perhaps the best illustration of insect association with the bacterial plant pathogens can be given in a brief discussion of the bacterial wilt of cucurbits. This disease is caused by a vascular parasite, *Erwinia tracheiphila* Erw. Sm. and is known to be transmitted by two cucumber beetles,

Diabrotica vittata (F.) and *D. duodecimpunctata* (F). This bacterial disease in all appearances is entirely dependent upon these two species of insects for its spread and inoculation. The survival of the pathogen itself through the winter is wholly dependent upon these insects.

Only a small percentage of overwintering cucumber beetles may carry pathogenic bacteria within their digestive system, but these few cause primary infection and establish foci for secondary infection throughout the season. No other method of survival of *Erwinia tracheiphila* is known in nature. The importance of beetles in dissemination and inoculation is obvious. It becomes even greater when we stress the fact that this organism quickly loses its virulence on best known artificial media, yet it can live for months and survive winter within the insects without losing its viability and virulence. This is the only bacterial disease of plants known to be entirely dependent upon insects for dissemination and survival of its causal organism. The relationship between the insect and bacteria is obviously biological and obligatory in nature, as shown by Smith (1911), Rand (1915), Rand & Enlows (1916), Rand & Cash (1920).

Potato Blackleg.—This is another bacterial disease of importance. It does not entirely depend upon insects for its development, yet the role played by the seed-corn maggot, *Hylemyia cilicrura* Rond. and possibly *H. trichodactyla* is by no means small. It has been established by Leach (1926) and supported by Bonde (1928) in a series of publications that the relationship between the maggot and the causal organism, *Erwinia carotovora* (Jones), is biological, although not obligatory. This insect disseminates bacteria and inoculates the seed pieces of potatoes and frequently breaks through the corky layers, thus preventing the isolation of inoculum from the healthy tissue of the potato. Leach (1933) showed that the causal organism apparently propagates within the adults and larvae, and may survive winter within the insect puparia. Upon emergence of flies in the spring the organism contaminates the emerging adults for another cycle of dissemination and infection in nature. Bacteria evidently are also necessary for normal development of larvae on potatoes and other vegetable crops.

Soft Rot of Vegetables.—This is caused by the same bacillus, *E. carotovora*, and the relationship between the microorganism and several maggots is much the same as described for the potato blackleg. The soft rot of crucifers is one of the best examples. In descriptions of the injury caused by the cabbage maggot, references are often made to the decay of the roots and stems of young cabbage transplants. This decay usually starts at and follows the maggot wound injury. It often progresses from the roots through the stem upward into the head of crucifers, causing the internal rot and wilting of the plants. The organism, *E. carotovora*, is spread by the cabbage maggot *Hylemyia brassicae* (Bouché) in the process of oviposition as shown by Johnson (1930).

The Heart Rot of Celery.—This is similarly spread by dipterous insects, *Elachiptera costata* Loew and *Scaptomyza graminum* Fall. Infection always begins at the initial point of larval penetration into the plants as demonstrated by Leach (1927).

There is a long list of other bacterial diseases of truck crops in development of which insects have part, although usually as mechanical carriers or wounding agents, facilitating bacterial infection. It is well to point out that, though there is much stomatal infection, many bacterial phytopathogens depend upon wounds for infection of plants. The capability of insects in wounding plants hardly can be surpassed.

The following additional bacterial diseases of vegetables are shown to be insect disseminated. Black rot of crucifers, *Bacterium campestre* (Pam.) is disseminated by cabbage looper, *Autographa brassicae* (Riley); Bean bacteriosis, caused by several strains of *Bacterium phaseoli* Erw. Sm., is spread by thrips, *Heliothrips femoralis* Reut.; Spot disease of cauliflower, caused by *Erwinia maculicolum* McCulloch, is disseminated by the red border stink bug; bacterial wilt of Solanacae, such as potato, tomato, pepper and related plants caused by *Bacterium solanacearum* Erw. Sm. is spread by flea beetles, blister beetles and certain other insects as shown by Smith (1911).

INSECTS AND VIRUS DISEASES.—The number of virus diseases of truck crops is

impressively large, and new diseases are being periodically reported. They are believed to be caused by a filterable infective principle. The question, "Is this principle living or non-living?" is of no particular interest here. It is known, however, that many of these so-called virus diseases are insect transmitted. It will be impossible to cover the entire range of virus diseases of truck crops, and of necessity I must restrict myself to only a few striking examples of apparently different types of transmission.

There is a group of viruses affecting the truck crop plants that can be transmitted by insect vectors with astonishing ease, though some of these viruses are only with difficulty inoculated by the extract from diseased plants. Among the viruses so easily transmitted are the following:

Onion Yellow Dwarf.—This is claimed by Drake *et al.* (1933) to be successfully inoculated by feeding of over 50 different species of aphids.

Bean Mosaic.—According to Zaumeyer (1933) and Zaumeyer & Kearns (1936), this can be transmitted by about a dozen different species of aphids and probably any species that may casually feed on infected plant is potentially able to mechanically inoculate a healthy plant on subsequent feeding, provided the viability of the virus in or on the feeding stylets is not lost.

Potato Spindle Tuber and Potato Unmottled Curly Dwarf.—These are reported to be transmitted by such insect vectors as *Epitrix cucumeris* Harr., *Lygus pratensis* (L.), *Melanoplus* sp. *Systena taeniata* Say and several species of aphids, as shown by Goss (1931).

Cauliflower Mosaic Virus.—As reported by Smith (1937), this is usually transmitted by aphids, such as *Myzus persicae* (Sulz.), *Brevicoryne brassicae* (L.) and *Rhopalosiphum pseudobrassicae* (Davis), habitually feeding on crucifers, and also experimentally by about a dozen other aphid species not habitually found feeding on these plants.

Some viruses while on their original hosts, from which they are described or by which they are known, produce systematic symptoms of the disease, yet they may induce only local lesions when sap is inoculated into certain differential plants. It is of interest to point out that a similar or identical type of local lesions may be produced on the same differential host by feeding of viruliferous aphids infected with the virus in question. The transmission of the cauliflower and broccoli ring spot virus to tobacco, *Nicotiana tabacum* by *Myzus persicae* (Sulz.) is a very good illustration of this phenomenon.

There are several viruses of truck crops that apparently require a so-called "incubation period" within the insect vector before the infective entity can be transmitted to a healthy plant as shown by Severin (1921, 1924), Swezy (1925) and others. Among such viruses are potato leaf roll, requiring a minimum of 24 hours in *Myzus percicae* (Sulz.); curly top of sugar beet virus requiring several hours of incubation in *Eutettix tenellus* (Bak.); spotted wilt of tomato requiring about 5 to 9 days in thrips, *Frankliniella insularis* Frankl. Other viruses such as pea mosaic and latent virus of potatoes have their own minimum incubation periods within the insect vectors.

This fact, as well as the specificity of the transmission of certain viruses, such as in the cases of sugar beet savoy disease by *Piezma cineria* Say; curly top of sugar beet by *E. tenellus* (Bak.) and other cases, suggest the biological transmission of certain viruses. It is not excluded, however, that the so-called "incubation period" of a virus within the vectors may prove to be dependent upon the size of the organism, if it is a living entity, or upon the size of the molecule if it is an autocatalytic protein. The ability of the virus to pass through the intestinal wall and to the salivary glands may well be dependent upon these factors. It may be only a mechanical obstruction in filtering the virus, whereas the perpetuation of the virus requires active cell metabolism.

The complexity of the virus problem is further accentuated by the fact that two or more viruses may be present at the same time in the affected plant. The composite nature of viruses cause interaction of symptoms and a plant may exhibit a new set of visible symptoms in its complex. Potato viruses especially are found in combination with others. It is of interest to note that certain insects exhibit remarkable selectivity with regard to viruses. Some of the insects if allowed to

feed upon affected hosts can take up one virus out of the "complex," leaving another virus in the host, as demonstrated by Hoggan (1929, 1933), Smith (1931) and others. Crinkle disease of the potato consists of two viruses, healthy potato virus and super mild mosaic virus. Crinkle is not transmitted in its entirety; only the super mild mosaic virus can be transmitted by *Myzus persicae* (Sulz.) and *Aphid rhamni* Kalten. Recently Hoggan (1929, 1933) showed that *M. persicae* (Sulz.) can transmit only the cucumber mosaic virus from the combination of the tobacco mosaic virus and the cucumber mosaic virus in the same host.

In certain instances, as has been shown by Samuel *et al.* (1930), the adult thrips, *Frankliniella insularis* Frankl., and other thrips, as shown by others, are not able to pick up the virus. Only in the larval stages do these insects become infective, but once they become infective they can retain the viruliferous condition not only through the larval stages, but also through the adult life. However, in the case of the tingid bug, *Piesma quadrata* Fieb., the nymphs are not able to transmit virus of the sugar beet crinkle. It is transmissible only by the adults.

INSECTS AND TOXICOGENIC DISEASES.—Only in passing it should be mentioned that there are several important diseases of truck crops that are apparently due to feeding action of sucking insects and possible injection of toxins into the plants during the process of feeding. The potato hopperburn and the psyllid yellows of the potato and the tomato are perhaps the best illustrations of this type of plant diseases or disease-like insect injuries.

The feeding of sucking insects, such as leafhopper, aphids, scale insects and others, which constantly extract the plant juices needed in the building up processes of the plants, doubtless upsets the equilibrium of the delicately adjusted balance in the physiological functions of the plant. In addition to actual withdrawal of plant sap, there is an obstruction in translocation of photosynthetic products, which results in the accumulation of sugars and starch in the affected plant tissues as shown by the writer and confirmed by others. This subject was briefly discussed by the writer (1930, 1931) before. The results of such feeding often produce various types of malformations, stunted growth, withered limbs and even premature death of plants. This in turn profoundly injures the market and keeping quality of vegetables and truck crops.

CONCLUSION.—The writer is of the opinion that we have already passed through a preliminary period of uncertainty in the realm of insects in relation to plant diseases. We are no longer feeling out the ground within the boundaries of this borderline province. From the purely speculative phases of the subject, we have definitely entered a second period in the development of this interesting field.

The present period is characterized not only by the continuous addition of fragmentary knowledge of insect transmission of various plant diseases and the development of suitable methods, but it is also characterized by the critical evaluation of accumulated data and the discriminate summation of our past achievements. Although new viruses are being steadily announced and new evidences of insect relationship are being presented, we are in the period of stabilization of nomenclature and classification of plant viruses, many of which are insect borne; we are in the process of development of improved and refined methods employed in experimentation, no longer of an empirical nature but based upon deductive and inductive reasoning as to the possible relations of insects and plant diseases; we are passing through the times of crystallization of our concepts of the principles involved in this tri-cornered association between the insect, pathogen and the suscept, each of which has its own optimal ecological requirements.

Our knowledge of this field is advancing with astounding rapidity. I believe that we are on the threshold of a new period. Interested workers, both plant pathologists and entomologists with the aid of plant physiologists and biochemists, will blaze new trails in the realm of insects in relation to plant diseases by field and laboratory research. I believe new problems of economic import will be opened, establishing new associations of scientific interest between insects and microorganisms, developing new methods of approach, producing new and precise technique, inventing new and more efficient apparatus capable of utmost rigidity in

the control of experimental conditions. Finally, I believe we are on the threshold of the development of a new attitude for more accurate precision in the measurement and treatment of research data obtained in these extraordinary interesting and complicated interactions between the various factors concerned.

In blazing these new trails, the entomologist has a definite place. He has a definite role to play and work to do. He can be of service either alone or in cooperation with the workers in related fields, especially that of plant pathology. In either case the best progress can be made by individuals thoroughly trained in the fundamental principles and adequate technique in both the fields of entomology and plant pathology. In addition to this, the entomologist should have an invincible urge to know more about the entire field with all the phenomena involved in the role insects play in the spread of phytopathogens and in the development of plant diseases.—1-7-38.

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Discussion of Symposium Paper by A. A. Granovsky

D. M. DELONG, *Ohio State University*

Disease in the plant may be defined as an abnormal condition which impairs the plant in carrying on its normal physiologic and growth processes. This might be produced by various conditions and be manifest in various ways. For instance, the disease condition might take the form of discoloration or pigmentation, atrophy or hypertrophy, wilting or death of various parts. The insect is able to produce a disease condition in plants in at least two different ways: first, by the transmission of organisms—protozoan, bacterial, fungus or virus—through feeding habits especially; and, second, by direct feeding injury to the plant tissues. Dr. Granovsky has outlined the first of these types in the paper which he has just presented and I would like to supplement his discussion with a few brief remarks regarding the direct feeding injury.

Both chewing and piercing-sucking types of insects may cause this condition but the majority of feeding injury which is confused with or attributed to injected organisms is caused by the latter type of insect, especially by the true bugs (Hemiptera) or various types of Homoptera, especially Aphiidae, Psyllidae (Chermidae), Fulgoridae and Cicadellidae.

Different species of insects belonging to these groups may cause entirely different types of injury upon the same plant by different methods or habits of feeding. This is characteristic of the species of the genus *Empoasca*. Several of these species, *arida*, *abrupta* and *filamenta* for example, feed upon beans and potatoes but seem to injure only the mesophyll tissues, while *fabae* commonly feeds upon the phloem and xylem and apparently mechanically obstructs the normal functioning of these vessels. This apparently interferes with both the water conduction and translocation of manufactured products of the leaf and is apparently the cause of the disease condition known as "hopper burn."

The statement has frequently been made that hopper burn is due to injected toxins produced by the insect, but scientific investigation has failed to give proof of this statement. Similar types of feeding frequently produces conspicuous pigmentations upon plant tissues. Chenopodium leafhoppers produce this condition upon the lambs-quarter and when this insect becomes established upon closely related economic plants such as Swiss chard and spinach the same pigmentation, bright red in color, will occur upon the leaves of these plants. This is also apparently caused by mechanical injury which prevents the translocation of manufactured sugars. Those insects which feed upon the mesophyll tissues cause localized injury by the destruction of small areas of cells or, many times, the destruction of the chlorophyll.

In this way disease conditions are produced by the insect interfering with normal functions of transpiration, respiration, photosynthesis and translocation. As a consequence, the plant is severely stunted or impaired in its production of economic products. In many cases death may result very shortly because of the direct feeding of certain types of insects.

THE OREGON quarantine order relating to virus diseases of *Rubus* was revised on November 10 to apply to all states. The plants may enter certain counties under permit and certain other counties in the state under an inspection certificate.

THE common barberry and certain other species of *Berberis* determined to be alternate hosts of the black stem rust may not be grown or shipped in Pennsylvania, under quarantine established by that state on October 18.

Insects in Relation to Diseases of Fruit Trees and Small Fruits

L. O. Kunkel, *The Rockefeller Institute for Medical Research, Princeton, N. J.*

You may be disappointed to learn that, in discussing the relation of insects to spread of diseases of fruit trees and small fruits, I am obliged to confine myself almost entirely to one insect that spreads a virus disease of a fruit tree. This is necessary not because of the time limit set but because I have not worked with insects that spread small fruit diseases or with insects that spread other fruit tree diseases. As you may have guessed, the disease which I will attempt to discuss is peach yellows and the insect *Macropsis trimaculata*. If you will bear in mind the fact that little is known regarding the manner in which this insect spreads yellows, you will perhaps pardon some digression from the subject assigned me.

Two Types of Transmission.—There are two distinct types of transmission of plant viruses by insects. The first type is believed to consist in a simple mechanical transfer of virus from a sick to a healthy plant. Mouth parts, having become contaminated from contact with the tissues of a diseased plant, inoculate virus into wounds made when these organs are used to penetrate the tissues of a healthy plant. Ability to transmit is acquired immediately after the insect first feeds on the diseased plant and is lost soon after it leaves the plant. Examples of this kind of transmission are found among the insects that spread highly infectious virus diseases.

The second type of transmission is more complicated than the first. The insect concerned is not able to transmit virus immediately after first feeding on a diseased plant. A definite period must elapse between the time when it first feeds on the sick plant and the time when it acquires the ability to transmit. This interval, which for different vectors and different viruses varies from a few hours to ten or more days, is usually designated as the incubation period of the virus in the insect. Vectors that require such a waiting period before gaining ability to transmit always retain this ability for a relatively long time. They frequently retain it as long as they live. There seems to be a definite connection between the necessity for an incubation period and retention of the ability to transmit. Examples of this type of relationship are found among insects that spread diseases refractory to transmission by mechanical inoculation. Peach yellows and practically all of the other virus diseases of fruit trees and small fruits belong in this class.

What happens in the body of an insect during the incubation period? Why are viruses that require incubation retained so tenaciously by their vectors? These questions have not yet been satisfactorily answered, but there is evidence that in certain cases at least the incubation period is a period during which virus multiplies in the body of the vector and that long retention of virus is possible only because of such multiplication.

Habits of *Macropsis trimaculata*.—The leafhopper, *Macropsis trimaculata*, is known to transmit peach yellows and little peach, two diseases believed to be caused by strains of the same virus. None of the other insects that live on peach trees seems able to do this. *Macropsis trimaculata* lives on both the peach and the plum. It is usually found in larger numbers on the plum than on the peach, especially late in July. However, it can live generation after generation on peach trees. As many as 400 nymphs were taken from single six year old peach trees in 1934. The insect is occasionally found in even greater numbers on old peach trees. However, it is not a numerous leafhopper even during seasons when it is most abundant. This is partly due to the fact that it produces only one generation a year. Eggs laid on the twigs of peach trees during July and August will not hatch until late in May of the next year. Most individuals reach the adult stage late in June and die of old age before August 10. An excellent account of the life history of *Macropsis trimaculata* has recently been published by Hartzell.

The insect is a strong flier. It can, and no doubt does, with the help of the wind, travel long distances at times. However, it is not easily forced into flight. Most individuals do not normally move very far

from the tree on which they hatch. There is reason to believe that many spend their entire lives on the mother tree. This is fortunate, for if the insect were of a roving nature peach yellows and little peach might spread much more rapidly than they do. It is also fortunate that the insect is, in some seasons at least, an inefficient transmitter. During three summers considerable numbers of both nymphs and adults were collected from trees with little peach in orchards near Clinton, N. J. The insects were confined on young peach trees in cages in greenhouses at Princeton, N. J. A few transmissions were obtained from exposures made in the early part of each season, but hundreds of insects kept for a month or longer on healthy peach trees failed to transmit. Each year insects taken from healthy appearing orchard trees were confined for from one to two weeks on caged trees having yellows. Other insects were confined for similar periods on trees having little peach. They were then kept on healthy trees for varying periods of time, but in no case did they transmit either yellows or little peach. The inefficiency of the vector has handicapped efforts to identify an incubation period of the virus in the insect or to determine the length of time the virus is retained by the insect.

EFFECT OF HEAT ON VIRUS.—The fact that so many colonies failed to transmit was very puzzling until experiments made during 1934 and 1935 showed that peach trees having either yellows or little peach can be cured by heat treatments. Temperatures as low as about 95° F. proved effective. Bud sticks having either disease were always cured by immersing them in water at 122° F. for as short a period as 4 minutes. They were usually not cured when immersed for 2 minutes or less. Peach buds were found capable of enduring treatments lasting six times as long as was necessary to free them of virus. The experiments were interpreted as showing that yellows and little peach viruses are inactivated by moderately high temperatures. If these viruses can be inactivated in peach tissues by exposure of the tissues to a temperature of 95° F., why may they not be inactivated in the vector when the latter is exposed to an equally high temperature? Most of the transmission tests were carried out during the month of July when greenhouse temperatures of 90° F. or higher were not unusual. Moreover, the temperature inside cages used to confine the insects was always somewhat higher than that of the air in the greenhouses.

The possibility that yellows and little peach viruses were inactivated by the temperatures to which the insects were exposed offers an explanation for the small number of transmissions obtained in the experimental tests. Inactivation of the viruses in the insect under natural conditions by temperatures that prevailed during the time when the leafhopper was most numerous and was in the adult stage also offers a possible explanation of the slow rate of spread of yellows and little peach during these years. A demonstration that the efficiency of the vector is affected by summer temperatures and can be experimentally increased by keeping the leafhopper cool has not yet succeeded. The years 1936 and 1937 were poor for *Macropsis trimaculata*. This fact and other circumstances beyond control have up to the present time prevented suitable experimental tests.

EXPERIMENTS WITH *Macrosteles divisus*.—During the past year experiments were made in which the aster leafhopper, *Macrosteles divisus* (*Cicadula sexnotata*), was substituted for *Macropsis trimaculata* in tests originally designed for execution with the latter.

Macrosteles divisus is available at all times from colonies maintained throughout the year. Preliminary experiments showed that the aster leafhopper is able to endure a temperature of 90° F. for many days. Preliminary experiments also brought evidence that the aster yellows virus is similar to peach yellows and little peach viruses in its reaction to heat. Tests were, therefore, undertaken to determine whether or not it would be possible to inactivate this virus in the aster leafhopper by temperatures reached on hot summer days. It was soon found that virus-bearing leafhoppers always lost the ability to transmit aster yellows when exposed to a temperature of about 90° F. for as long as one day. However, the insects quickly regained ability to transmit without again feeding on a diseased plant when the temperature was lowered by about 15° F. Colonies held at 90° F. for a week also regained ability to transmit when subsequently held at a lower temperature, but

they regained it much more slowly than those that were heat treated for only one day. Colonies treated for one day usually regained ability to transmit a few hours after treatment, whereas colonies treated for a week always required two days or longer to regain this ability. Colonies treated for 12 days or longer lost permanently the ability to transmit.

The results are interpreted as indicating that a one-day treatment inactivates a fair portion of the virus carried by the insects, a one-week treatment a much larger portion and a 12-day treatment all of the virus. If, as seems likely, loss of ability to transmit is due to loss of virus by heat inactivation, and if the rate of inactivation of aster yellows virus in the vector follows a curve similar to that published by Price for heat inactivation of tobacco mosaic virus *in vitro*, the concentration of virus in an aster leafhopper being exposed to an inactivating temperature will fall rapidly at first. It will fall more slowly as an end point is approached.

That insects under treatment lose the ability to transmit long before all of the virus carried is inactivated was proved by the fact that temporary loss of ability to transmit always resulted from treatments lasting as long as one day, while permanent loss of ability to transmit never resulted from treatments lasting less than 12 days.

If loss of ability to transmit is due to reduction in concentration of the virus in the body of the insect to a sub-infective level, then recovery of ability to transmit must result from an increase in the concentration of virus. How can such an increase take place? Obviously, by multiplication of virus in the body of the insect. It is possible to obtain at will, by heat treatments of appropriate lengths, heat-induced incubation periods that are either very much shorter or considerably longer than the minimum natural incubation period. This suggests that short heat treatments reduce the concentration of virus in the insect to a level only slightly below that necessary for transmission, whereas long heat treatments reduce it to a level lower than that resulting from infection through feeding on yellows plants.

CONCLUSIONS.—An objection has been raised to the conclusion that either temporary or permanent loss of ability to transmit following a heat treatment is due to inactivation of virus in the leafhopper. The effect might be on the insect rather than on the virus. It may be said, in answer to this objection, that there is no evidence of any injurious effect on the leafhoppers. They can feed, grow from small newly hatched nymphs to the adult stage, produce fertile eggs and live what appear to be normal lives when held continuously at 95° F., a temperature 5° F. higher than that which in one day invariably causes temporary loss of ability to transmit. Insects that have lost permanently the ability to transmit may reacquire this ability by feeding on a diseased plant. This proves that the capacity of the insect to become infective is not impaired by the treatment. Therefore, the effect must be on the virus. Moreover, heat treatment experiments brought evidence of inactivation of virus in the aster plant as well as in the aster leafhopper.

The experiments are believed to justify the conclusion that exposure of virus-bearing leafhoppers to a temperature of 90° F. for about 12 days inactivates all of the virus carried by the vector. Studies on heat-induced incubation periods in the aster leafhopper suggest that these periods represent intervals during which virus multiplies in the body of the insect. It is probable that multiplication also occurs during the natural incubation period and that this is the basis of the specific relationship existing between *Macrosteles divisus* and the aster yellows virus.

The work with the aster leafhopper makes it seem probable that the inefficiency of *Macropsis trimaculata* as a vector of peach yellows and little peach either in the orchard or in experimental tests may be due in part at least to the low thermal inactivation points of the viruses concerned. The sensitiveness of peach yellows virus to high temperatures suggested the heat inactivation experiments with aster yellows virus. These experiments furnish a pattern for further experiments on the relation of *Macropsis trimaculata* to the spread of yellows and little peach. It is to be hoped that both lines of work may contribute something toward a better understanding of the relations between other virus diseases and the insects that cause their spread.—1-6-38.

Discussion of Symposium Paper by L. O. Kunkel

ED. M. SEARLS, *University of Wisconsin, Madison*

It is a real privilege to have been here and heard Dr. Kunkel's report of these new findings. I believe that this discovery is an outstanding contribution in the field and will take its place with the discovery by Storey that the ability to transmit virus diseases is in some cases heritable and apparently associated with the permeability of certain insect tissues to the virus, and with the discovery that incubation periods are necessary for certain insects to become vectors of a virus and with the demonstration of the selective action of insects for certain viruses.

VIRUS AND INSECT VECTORS.—These findings have enabled us to understand, as well as we do, the strange phenomenon of insect vectors of virus diseases. Science, and humanity as well, are the richer because of these findings for it appears that the insect relation to the virus is the most practical point of attack on the problem of the control of insect transmitted virus diseases. We know very little of the nature of a virus. There are certain theories, each with its adherents, but we are not sure, as yet, whether a virus is a living entity, a very potent catalyst, or a form of protein. We do know however that most viruses may be transmitted by insects and that, in some cases, the virus may be carried from host to host by insect vectors only.

It has not been demonstrated that there is any symbiotic relationship between a virus and the insect vector. The insect does not appear to profit in any way from the presence of the virus. The virus gains to the extent that it is perpetuated by being carried to new hosts. There are suggestions of other relationships. For example, in some cases the phenomenon of mass action appears to account for the success of weak vectors in carrying a virus from one host to another when single insects repeatedly have failed. Selectivity of insect species for a certain virus and specificity of a virus for individual insects or strains of insects are other relationships that have been noted.

SELECTIVITY.—Dr. DeLong in his discussion of Prof. Granovsky's address mentioned the fact that certain sucking insects are mesophyll feeders while others are phloem feeders and suggested that this might account for the ability of some species of insects to transmit a certain virus where others could not. This is a probable explanation of selectivity. We know that when a tobacco plant is infected with the virus of both tobacco mosaic and cucumber mosaic, the green peach aphid, *Myzus persicae*, will transmit the virus of cucumber mosaic from a diseased plant to a new host to the exclusion of the other virus. In specificity we find the probable explanation of the reason one insect within a family or one strain of insects within a species is able to transmit a virus while others could not. This may also be the explanation of apparent mass action phenomenon.

Dr. Kunkel's discovery of the relation of temperature to the relative ability of an insect to transmit a virus has given us another means by use of which we may understand further these phenomena of mass action, selectivity and specificity, but more particularly the erratic behavior of vectors in the hands of different workers in different seasons and in different climates.—1-7-38.

Insects in Relation to Diseases of Shade and Forest Trees*

J. G. LEACH, *University of Minnesota, St. Paul*

NOTE.—*The author exhibited a two reel motion picture telling the story of the association of bark beetles and blue-stain fungi in Norway pines. It was taken at the Itasca Park Forestry and Biological Station, Itasca Park, Minn., and based on experimental work carried out by J. G. Leach, Leslie Orr and Clyde Christensen of*

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the Minnesota Agricultural Experiment Station as part of a cooperative research project of the departments of plant pathology and entomology, dealing with the general problem of insects in relation to plant diseases.

This film is a popular visual presentation of the experimental results published in the Journal of Agricultural Research 49:315–342, 1934. The film shows the methods used in experimentally proving that the blue-stain fungi are introduced into Norway pine trees by two species of bark beetles. Following the experimental proof of the association, the life histories of the beetles and the associated fungi are shown by close-up pictures or pictures taken through the microscope. The film also shows methods of control used in keeping down the population of beetles with the aim of conserving the pine trees that constitute one of our most valuable natural resources.

The picture was made as an experiment in visual education with particular reference to use of motion pictures in the presentation of the results of scientific research. It was made in the field and in the laboratory while the experimental work was in progress, and the film was presented to the public several months before the technical report appeared in print.

The similarity of the relationship between the pine bark beetles and the blue-stain fungi to the association of the elm bark beetles and the fungi causing the Dutch elm disease adds to the interest of the film. It should be noted that the pine bark beetles, unlike the elm bark beetles, do not have the habit of feeding on the twigs of vigorous trees before penetrating the weakened tree to establish breeding tunnels. For this reason vigorous pine trees are rarely if ever infected with blue stain. Inasmuch as both beetles require weakened trees for the establishment of breeding tunnels this difference in feeding habits probably accounts for the more acute and more epidemic nature of the Dutch elm disease.

The picture was taken by V. P. Hollis, University of Minnesota photographer, with a Bell and Howell camera on standard 35 mm. film. Positive prints are available on both 35 mm. and 16 mm. film. The films may be rented from the Department of Visual Education of the University of Minnesota at a nominal rate.—1-5-38.

Insects in Relation to Diseases of Cereal and Forage Crops

F. W. Poos, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*

In discussing the subject of insects in relation to diseases of cereal and forage crops, it seems well to refer for a moment to the paper by Rand & Pierce (1920) entitled "A Coordination of our Knowledge of Insect Transmission in Plant and Animal Diseases." This very excellent review includes a bibliography of 173 references, about one-half dozen of which refer to the transmission of animal diseases. Of the other 167, only 15 refer directly to diseases of cereal and forage crops. To analyze further, 7 of these 15 refer to sugar cane, 5 to grasses and 1 each to oats, peanuts and wheat. Several of them refer largely to infection through insect wounds without dissemination by the wounding agent, or, as in the case of some of the earlier references cited (1884 and 1887), they merely suggest that insects aid in the propagation of certain diseases such as ergot, where the glittering saccharine liquid exuded by ergot is eagerly sought after by flies. Other references are cited in which the insects were described as mechanical carriers of spores, etc. Because of the abundance of the insects involved, their importance as vectors was presupposed.

OTHER STUDIES.—On December 31, 1921, a symposium on the subject of "Insects as Disseminators of Plant Diseases" was held at a joint session of the Phytopathological Society and the American Association of Economic Entomologists at Toronto, Can. At that time only one slight mention of diseases of cereal and forage crops was made. Frederick V. Rand (1922) mentioned corn stalk and ear molds along with several other bacterial and fungous diseases in which insects were considered as bearing a really important relation to their spread, either directly as actual carriers of infection or

indirectly by providing wounds through which the organisms might enter.

It is obviously not within the scope of this paper to discuss in detail all of the several hundred reports, existing in the literature today, of instances in which diseases of cereal and forage crops were known or suspected to have been transmitted by insects. In summarizing the literature on but a single phase of the subject of this symposium, the writer has faced a task of considerable size and some difficulty, since the past decade has witnessed an enormous increase in the complexity of the problem and in the volume of literature on this subject. An attempt to condense such material into a paper of reasonable length necessarily has resulted in omissions, and has presented difficulties in the handling of conflicting evidence. It is hoped, however, that this paper will serve its purpose on this program as an aid in bringing the field of research on insect dissemination of plant diseases into at least an approximate focus so that the importance and promise of such research may become more evident.

Statements made in the past by many different investigators on the needs of various types of work in the field of insect transmission of plant diseases are as true today as when originally made. The need for a more nearly complete knowledge of insect vectors, their habits and host plant preferences, their relationship to the disease entity they bear, etc., still exists in far too many instances. It therefore seems unnecessary here to stress further the great need of detailed studies in this field, but rather to emphasize the need for, and the apparent difficulty of, enlisting the general interest of entomologists in this type of research.

INSECT VECTORS.—It is commonly conceded that one of the most important roles played by insects is their dissemination of virus diseases. Most entomologists appear to be concerned more with the direct result of insect attack than with the indirect injury that occurs through the relationship of insects to the transmission of diseases. Possibly one important reason for this is that many entomologists are not properly equipped to undertake the complicated technique required in the careful study of these problems. No field in entomological research offers greater fascination and promise for the student and the research worker. This is true not only because of its academic interest and the mystery surrounding the origin of the diseases, but also because of the limited information available, in many cases, on the bionomics and control of the insects involved.

In bringing together what is more or less a list of instances of interest (some of great economic importance) in which insects have served as vectors of diseases of cereal and forage plants, no hard and fast lines of classification can be drawn. For the sake of simplicity the data discussed are, for the most part, grouped according to the host plants of the diseases treated herein. There is necessarily some overlapping, as it seems preferable to include mention of additional host plants at the point in the discussion where a disease is reported as common to more than one species of host plant and is transmitted to such plants by one or more species of insect vectors. Because of the writer's connection with studies on potato-leafhopper-injury to forage-crop legumes and with studies on insect vectors of bacterial wilt of corn, it is hoped that the more lengthy discussions of these subjects will be pardoned.

RICE

According to Katsura (1936), the earliest record of a biotically transmitted plant virus being transmitted by an insect is that of the stunt or dwarf disease of Japanese rice, transmitted by the leafhopper *Nephotettix apicalis* Motsch var. *cincticeps* Uhl. in Japan. Katsura cites publications regarding this disease appearing as early as 1890, and he briefly reports upon the severe ravages of the disease and refers to the tragic famines caused by it. An early one of these famines occurred in 1733 and caused the starvation of nearly 5 per cent of the total Japanese population at that time. As early as 1900 it was determined that this leafhopper was the only insect capable of producing the true stunt disease of the rice plant. It was not until 1908, however, that experimental work definitely proved that the stunt disease of the rice plant was of unknown and mysterious origin, the causative agent evidently being carried by the leafhopper *N. apicalis*.

All attempts by Fukushi (as reported

by Katsura) at various mechanical means of transmission have given only negative results, and this investigator is inclined to believe that the transmission of the virus responsible for the stunt disease of rice is possible only by means of the leafhopper which is the specific biological carrier. All attempts to detect the virus in some form within the insect vector have failed. While it is not known how the virus is carried in the body of the insect vector, recent studies by Fukushi have shown that it is carried through the eggs—a unique discovery of outstanding importance in the field of insect transmission of plant diseases. Fukushi reports that the progeny receive the virus prior to the release of the egg and that an astonishing phenomenon must take place in the body of the viruliferous insect. The virus is thought to enter during the very early stage of egg formation in the ovary. Fukushi believes that the eggs become infected in the ovaries and states that "ovaries, therefore, must not be left out of consideration."

It would seem that the review by Katsura of the Japanese investigations on the dwarf or stunt disease of Japanese rice should be highly commended. Similar summaries of information on many of the common plant diseases transmitted by insects would serve a very useful purpose, even though the results of the original work may have been published in English.

CORN

VIRUS DISEASES.—A number of virus diseases of corn known as mosaic, streak, stripe or mottle, and having insect vectors, have been reported from various parts of the world. Of extraordinary excellence is the work with these diseases and their insect vectors in Africa by H. H. Storey, who first (1924) described streak disease of corn, or maize as it is called there, and later (1925) reported its successful transmission by means of the leafhopper *Cicadulina* (*Balclutha*) *mbila* Naudé, which was held to be the agent of spread of this disease in the field. This author (1926a) determined that the virus of streak disease of corn could not be transmitted to sugarcane (except a transitory infection from which it completely recovered), although the leafhopper did transmit the virus of sugarcane streak from infected to healthy sugarcane plants, and to healthy corn in a sparse form. Streak of *Eleusine indica* and *Digitaria horizontalis* transmitted to corn gave an intermediate form of streak. Infection by the sparse form did not immunize against infection by the normal form.

Attempts to alter experimentally the virulence of the streak virus failed. In the same year Storey (1926b) also reported that leafhoppers were the only means of transmission of this virus, that an incubation period in the insect occurred, that the power of infection was rarely lost by the leafhopper, and that (Storey 1926c) infective leafhoppers surviving the winter were able to infect early planted corn the following spring. The infective leafhoppers were later (Storey & McClean 1930) considered the principal source of the overwintering virus, rather than its perennial host plants.

Further work (Storey 1928) indicated no transmission through the egg and also the occurrence of non-viruliferous leafhoppers, whose offspring were capable, however, of becoming infective. The infective power of viruliferous leafhoppers was retained during the process of molting and usually throughout the entire life of the individual. The leafhopper could acquire the virus of corn streak after one hour's feeding on an infected plant. In comparative series of infection experiments with groups of leafhoppers and and single individuals, the average incubation period was shorter in the group series, but there was no difference in the minimum incubation period in each series. The severity of the disease produced in each case was the same, and Storey considered that the effect of a group of leafhoppers is the effect of the most virulent individual of the group, and is not the average effect or the sum of the effect of the members of the group.

Storey and McLean (1930), in attempts to transmit the streak disease with various insects, were unsuccessful with *Peregrinus maidis* (Ashm.), with which Stahl (1927) reported success in Cuba in transmitting a disease of corn hardly distinguishable by its symptoms from African streak disease. Storey (1932a) reported that, in addition to *Cicadulina mbila*, *C. zeae* China is a vector of streak disease of corn and that *P. maidis* transmits a rather similar disease occurring in the Amani district, the

virus of which may be identical with that of corn stripe in Cuba. He also reported (1932b) the results of detailed experiments showing that the ability to transmit is a hereditary character, races having been bred of which some are able and others unable to transmit the virus in the natural feeding process on corn plants. Crossing of pure races demonstrated that the ability to transmit is inherited as a simple dominant Mendelian sex-linked factor.

Storey (1933) reported on a method of inoculating inactive races of *Cicadulina mbila* and *C. zeae* with the virus of streak disease by puncturing the intestinal wall of adults, immediately preceding or following feeding on a diseased plant, with a finely pointed sterile needle or glass micropipette. It was concluded from these studies that, in the inactive insect, the cells in the intestinal wall resist the passage of the virus. The possibility of some secondary mechanism of resistance was recognized. *Cicadulina mbila* was not successfully inoculated in this manner with the viruses of corn stripe and of mosaic; nor were *Peregrinus maidis* and *Aphis maidis* Fitch successfully inoculated with the virus of streak.

The mechanism of the transmission of the virus of streak disease of corn by *Cicadulina mbila* was discussed further by Storey (1935a). Satisfactory proof was obtained that the stylets constitute the channel of the virus inoculation; also, that they must penetrate to the phloem for the inoculation to be successful. At this time Storey also reported that a normally fertile "active" line of *C. zeae* China proved to be infertile when crossed with a pure "inactive" line; microscopic examination revealed minute morphological differences between the two lines, making the author suspect that he was working with a group of closely similar species. Storey (1936) reported a new species, *Cicadulina storeyi* China (originally referred to as *C. nicholsi* by him), associated with *C. zeae* in studies recorded in 1935, but stated that experiments in progress suggest that the inheritance of activity or the power to transmit the virus of streak is hereditary in *C. zeae* and *C. storeyi* as in *C. mbila*.

A new virus of corn, transmitted by *Cicadulina mbila*, *C. zeae*, and *C. storeyi* in Tanganyika, which produces a transitory diffuse mottling in corn distinguishable from those of other viruses known to affect this plant, was reported by Storey (1937). Some of the leafhopper vectors were carrying both this virus and the virus of streak disease. The presence of one did not affect transmission of the other. The races of *C. mbila* and of *C. zeae* that did not transmit the streak virus (inactive races) transmitted the mottle virus in a small percentage of the tests. The presence of the mottle virus did not prevent the development of the streak virus, nor were the ultimate symptoms of one affected by the other. In some circumstances, however, the mottle virus caused a significant delay in the development of the symptoms of streak disease.

Brandes (1920) reported successful transmission of the sorghum mosaic virus to corn by means of *Aphis maidis;* also, the transmission of this virus from corn to corn and from sugarcane to sorghum by the same aphid. He concluded that the virus of corn mosaic is identical with that of sugarcane and sorghum mosaic.

Kunkel (1922) reported transmission of the virus of yellow stripe disease of corn from diseased to healthy corn in Hawaii by means of the corn leafhopper *Peregrinus maidis*, but all attempts to transmit it with this insect from corn to sugarcane were unsuccessful. He reported that *Aphis maidis*, when transferred from mosaic-infected corn plants, produced yellow stripe disease on healthy sugarcane. Kunkel (1927) reported that *P. maidis* from North Carolina was unable to transmit the virus of sugarcane mosaic of the United States to corn, although the insect was considered to be identical with the one which transmitted the virus of mosaic disease of corn in Hawaii. His results suggested that mosaic of corn in Hawaii was distinct from sugarcane mosaic and from mosaic of corn occurring in Louisiana and other Southern States.

Stahl (1927) reported the prevalent type of "mosaic" of corn in Cuba as causing severe injury manifested by a striping rather than a mottling. This type was readily transmitted from corn to corn by *Peregrinus maidis*, but not by *Aphis maidis*. The virus of sugarcane mosaic disease was transmitted to corn by *A. maidis*, but the symptoms were different from the striping, and the injury appeared to be less. All attempts to transfer the

corn striping to sugarcane failed; so the disease was considered distinct from sugarcane mosaic.

Shepherd (1929) regarded the so-called streak disease of corn, transmitted by *Cicadulina mbila*, and the stripe disease of corn, transmitted by *Peregrinus maidis*, as distinct diseases in Trinidad, since they had different insect vectors. Baker (1933) reported successful transmission of the corn stripe disease from corn to great millet, *Andropogon sorghum*. Stripe disease of corn apparently does not occur in continental United States, although its insect vector does occur here. The disease has been reported from Puerto Rico, Cuba, Trinidad, Tanganyika and Hawaii. It has not been transmitted through the seed.

Wellman (1934) reported transmission of celery virus 1 from *Commelina nudiflora* and celery to corn by *Aphis gossypii* Glov. Seedlings of teosinte, sweet-, milo- and Kafir-sorghums, wheat and rye were also successfully infected with celery virus 1 in the same manner. In greenhouse studies sweet, pop, flint and dent varieties of corn proved to be about equally susceptible. The celery virus causes a stripe disease of corn in Florida very similar to, but not identical with, the the white-stripe of corn in Cuba, according to observations made there by Wellman.

BACTERIAL WILT.—This disease of corn, also commonly called Stewart's disease, which is caused by *Aplanobacter stewarti* (E. F. Sm.) McC., is very destructive to sweet corn. It was first recognized as a disease by Stewart in 1897 on Long Island. Forbes (1894) indicated that this disease was present in Illinois as early as 1891, when he reported that the corn flea beetle, *Chaetocnema pulicaria* Melsh. (which at the present time appears to be the principal insect vector and source of the overwintering bacteria), was particularly abundant in central and southern Illinois in May and June, and that the plants in whole fields were wilted more or less and those in some hills entirely killed. During the years following, this disease was reported from many other states. Smith's monographic report (1914) gave the results of his intensive work and the history on this disease up to that time. Rand & Cash (1933) apparently were the first to report insect vectors of this disease. They investigated many phases of the problem during the period of 1918 to 1924 and published three preliminary reports on their work which included, as one phase of their study, dissemination by insects. They reported dissemination of this disease by the southern corn rootworm, *Diabrotica duodecimpunctata* (F.), the corn flea beetle, *C. pulicaria*, and the toothed flea beetle, *C. denticulata* (Ill.), when these species were transferred from diseased to healthy corn plants in cages.

Ivanoff (1932) reported studies showing that the pathogene may enter roots of corn plants grown in artificially infested soil through wounds produced artificially or by white grubs, the larvae of species of *Phyllophaga*. The same investigator (1933) reported that the corn rootworm, *Diabrotica longicornis* (Say), was found to be an underground agent of transmission of Stewart's disease of corn. Elliott & Poos (1934) reported that overwintered adults of *Chaetocnema pulicaria* harbored *Aplanobacter stewarti* and found that approximately 19 per cent of the overwintered beetles were harboring this organism in April before corn was planted. Poos & Elliott (1936) reported on the results of isolations made during 1934 from about 40 species of insects from different host plants and localities under varying conditions in the field, eight species having yielded the organism. Only two of these species, *C. pulicaria* and *C. denticulata*, yielded confirming evidence that they are vectors of this organism under field conditions. In field collections of adults of *C. pulicaria*, 0 to 75 per cent of the individuals in each collection yielded the wilt organism. In addition to corn, teosinte (*Euchlaena mexicana*) and Job's-tears (*Coix* sp.) were found to be hosts of *A. stewarti*. Infection was obtained both by needle inoculations and through the feeding of infective flea beetles, *C. pulicaria*.

During the spring of 1937 preliminary studies of the internal morphology of *Chaetocnema pulicaria* were made. A microscopic study of stained longitudinal sections through the alimentary tract revealed an abundance of bacteria, resembling *Aplanobacter stewarti* in size and shape, in the crop of this beetle. The organism is doubtless present throughout the entire alimentary tract, since inocula-

tions on healthy corn plants with inoculum made from feces of *C. pulicaria* macerated in distilled water have caused typical symptoms of the disease on such plants. In one instance positive symptoms were obtained with inoculum made from pellets of fecal matter that had been deposited a minimum of 48 hours previous to being placed in the distilled water. Similar tests indicated that the organism *A. stewarti* also passes through the alimentary tract of *C. denticulata* in a viable condition, but either not so abundantly or perhaps less virulently.

Strong (1936), referring to cereal and forage insect investigations, reported that, in addition to *Chaetocnema pulicaria* and *C. denticulata*, the spotted cucumber beetle, *Diabrotica duodecimpunctata*, gave positive evidence of being a carrier of bacterial wilt of corn under field conditions.

Frutchey (1936) reported that a wilt of corn was produced by either of two different organisms associated with *Aplanobacter stewarti*, and concluded that these organisms were parasitic and played a part in the appearance of Stewart's disease under some conditions. Apparently no further work on this point has been published. Frutchey also reported transmission of Stewart's disease by means of the seed-corn maggot, *Hylemyia cilicrura* Rond., especially "from the infected to the uninfected part of the seed"; also, that isolations of the wilt organism were made from both the exterior surface and from the alimentary tract of the maggot of this insect.

Of prime interest in connection with this disease at the present time is the reason for the cyclic appearance of epiphytotics. The Bureau of Entomology and Plant Quarantine and the Bureau of Plant Industry inaugurated cooperative investigations in 1936, in the North Central States as well as in the East, to determine this point, if possible. The use of resistant varieties and the numerous ecological and other factors involved in determining the occurrence and the abundance of the principal insect vectors make it extremely difficult to obtain accurate data over a wide area.

During 1937 a previously unreported egg parasite of *Chaetocnema denticulata* (apparently second in importance among the insect vectors of the wilt organism *Aplanobacter stewarti*) was found at Arlington Experiment Farm. Although the significance of this parasite in determining the abundance of this beetle is not known, this incident is recorded to illustrate the fact that until more is known about the principal insect vectors under field conditions it would seem to be a difficult matter accurately to predict outbreaks of a disease so closely associated with them.

Another factor involved, which apparently requires further investigation, was mentioned by Thomas (1934). In discussing the possibility of soil infection, he found certain material that contained a virulent bacteriophage which was very active against the corn wilt organism in pure culture and most active at a temperature below the optimum for the growth of *Aplanobacter stewarti*. Thomas (1937) reported finding bacteriophages, inhibiting growth and lysing homologous strains of *A. stewarti*, present generally in field corn and in some of the hybrid varieties of sweet corn. Is it unreasonable to suggest the possibility of the infective powers of an actively infective insect vector being influenced adversely by feeding on plants containing such phages?

Wellhausen (1937) has recently reported on the effect of the genetic constitution of the host on the virulence of the bacterial wilt organism. He found that virulence may be increased in a resistant host and decreased in a susceptible host of a particular species, and suggests that this fact may have an important bearing on the rise and decline of disease epidemics in that species.

Stevens (1934) reported on the relation of winter temperatures to the incidence of the disease and established a winter-temperature index (sum of the U. S. Weather Bureau monthly mean temperatures for December, January and February) at 100 Fahrenheit degrees or more which was favorable to the development of wilt in localities where wilt normally appeared, whereas an index of 90 Fahrenheit degrees or less appeared to be unfavorable. The exact significance of this relationship has not been explained; although, in general, the forecasts based on Stevens's hypothesis have been fairly accurate during the past three seasons.

Haenseler (1937) discussed the correlation between winter temperatures and the incidence of sweet corn wilt in New

Jersey from an analysis of the period of 1910 to 1937. He concluded that such a relationship definitely exists and that it may be used to advantage in predicting possible wilt outbreaks. He did not believe, however, that the relationship was simple enough to allow accurate quantitative prediction of wilt incidence without further study and evaluation of the time factor or lag period involved, because it seems that after a period of severe wilt a single cold winter is not sufficient to reduce the parasite or its carriers sufficiently to give the expected disease control. Likewise, after a period with little wilt the first warm winter may not be sufficient to permit the increase of the parasite or its carriers sufficiently to give a serious outbreak the following summer. Observations by the writer on the distribution and abundance of the principal insect vectors, as now known, indicate that factors other than temperature may be very important in influencing the number of individuals of these vectors that survive the winter and are capable of inoculating corn with *Aplanobacter stewarti* early in the corn growing season.

SUGARCANE

Reference has already been made, under the discussion of corn, to cross-inoculation studies, which included sugarcane. Pemberton (1936) briefly listed the insect vectors of virus diseases of sugarcane, starting with Fiji disease. *Perkinsiella saccharicida* Kirk. was reported as the insect vector of this disease in Australia, while in the Philippine Islands proof has been established that an allied species, *P. vastatrix* (Breddin), can transmit this disease. In the Fiji Islands it is thought that *P. vitiensis* Kirk. is the species largely responsible for the transmission of the disease, since it prevails in the cane fields there. It is thought probable that where more than one species of *Perkinsiella* occurs on cane in the same locality, several or all of them may act as vectors of the virus of Fiji disease.

Streak disease of sugarcane apparently is native to South Africa, and the only known method of transmission of the virus which causes this disease is by the leafhopper *Cicadulina mbila*, which is, however, a highly efficient vector, as one infective individual may be sufficient to produce infection. Froghopper blight of sugarcane in Trinidad and Granada, although exhibiting symptoms of a similar nature, is not considered a virus disease but rather an intoxication resulting from the feeding punctures made by the froghopper *Tomaspis saccharina* Dist.

Sugarcane mosaic is probably of most importance among the virus diseases of sugarcane. Ingram and Summers (1936) reported that until 1933 it had only one proved insect vector, that is, *Aphis maidis* Fitch, first shown to be a vector by Brandes (1920). Ingram and Summers discovered two additional insect vectors of the virus of sugarcane mosaic under controlled conditions, thus relieving *A. maidis* of its supposed status, since 1920, as the sole insect vector of sugarcane mosaic. The aphids *Hysteroneura setariae* (Thos.) and *Toxoptera graminum* Rond., although not so effective as *A. maidis* in transmitting the virus of sugarcane mosaic, may be responsible for many infections that could not be ascribed to *A. maidis*. *Hysteroneura setariae* is present in Louisiana and feeds on the cane throughout the year, whereas *A. maidis* is present there only in the winter and early in the spring.

Strong (1936), reporting on the results of research on the insect vectors of sugarcane mosaic in Puerto Rico conducted by Vandenburg and Tate, states that the aphid *Hysteroneura setariae* was confirmed as a vector of the sugarcane mosaic virus. A sedge aphid, *Carolinaia cyperi* Ainslie, was definitely shown, by these workers in Puerto Rico, to be a very efficient vector of mosaic, although it was not definitely proved to be of importance in the dissemination of mosaic disease in the field. Evidence of the ability of *Aphis nerii* Kalt. to transmit the virus of this mosaic disease was also obtained. In preliminary notes on the virus diseases of some economic plants in Kwantung Province (China), Ho and Li (1936) state that sugarcane mosaic is known to be carried by a mealybug, *Pseudococcus* sp., and a woolly aphid, *Oregma lanigera* Zehntner. Since the assigned leader of the discussion of this paper has made considerable progress in the study of insect vectors of sugarcane diseases, only brief mention of this topic is made at this time.

ALFALFA

VIRUS DISEASES.—Weimer (1934), reporting on studies on alfalfa mosaic, described the symptoms of this disease, which apparently is widely distributed in the United States. The pea aphid, *Illinoia pisi* (Kltb.), transmitted the virus of this mosaic from diseased to healthy alfalfa plants in 36.5 per cent of his tests.

Edwards (1936) reported on witches' broom, a virus-induced disease of alfalfa which occurs in New South Wales, Queensland, Victoria, and South Australia. It is characterized by marked dwarfing of the plant and considerable increase in the number of shoots produced from the crown. It has been experimentally transmitted by grafting and in one instance by mass populations of insects, but Edwards considers it highly probable that an insect vector is concerned with the transmission of the disease under natural field conditions.

DISEASELIKE INJURY.—Alfalfa girdle was the name given to a diseaselike injury consisting of the yellowing of the foliage of alfalfa which is caused by the three-cornered alfalfa hopper, *Stictocephala festina* (Say). According to Brown and Gibson (1922), alfalfa girdle is one of the most important diseases of alfalfa in Arizona. It was first reported in 1909 and attributed to a species of *Phoma*. Severe losses on account of alfalfa girdle have been reported from Mississippi, Louisiana and Alabama. The economic importance of this injury is attested by Duggar (1930), who reported that 10 to 80 per cent of the alfalfa stems in Alabama had been girdled by *S. festina*, the usual symptoms being yellowing of foliage, stunting of growth or death of the affected stems.

The diseaselike symptoms on alfalfa caused by the potato leafhopper, *Empoasca fabae* (Harr.), and known as yellow top, "yellows" or yellowing, have been observed for many years in the United States. More or less similar injury caused by the potato leafhopper to several other forage-crop legumes has been observed in recent years.

Among the early records of this injury to alfalfa is one by Stewart, French & Wilson (1908), who observed in New York State that alfalfa "seeded in 1904, turned bright yellow from an unknown cause." These investigators considered the cause to be sought underground. That they were observing the injury caused by the potato leafhopper cannot be questioned when they say, "In 1907 this occurred two or three weeks after the second cutting when the plants were seven to nine inches high. It commenced on a strip along one side of the field where the hay had been cut a few days earlier than on the remainder of the field." Again quoting, "On affected plants the lower leaves are green while the upper ones are more or less yellow, or, occasionally, purple. As a rule, the yellowing is much more pronounced on the distal than on the proximal portion of the leaflets. Although the yellow leaves do not fall, the growth of the plants is severely checked." With reference to climatic conditions these workers thought that dry weather seemed to favor it, and other workers have recorded the same observation.

Monteith and Hollowell (1929) state that the greatest damage was observed during periods of heat and drought. We know now that drought conditions with high temperatures are unfavorable to the development of this injury and that the presence of ample host material in a thriftily growing succulent condition, with temperatures between 85° and 90° F., are most conducive to a rapid increase in the populations of this insect.

During nearly two decades following the report of Stewart, French & Wilson, the occurrence of yellowing of alfalfa was reported by many workers, some of whom noted the association of leafhoppers with the yellowing, but it remained for Jones & Granovsky (1927) to demonstrate, under controlled conditions during 1926, that the leafhoppers were definitely responsible for the injury known at that time as "yellows."

In 1934 Poos and Westover proposed referring to the diseaselike injury caused by *Empoasca fabae* as potato-leafhopper-injury, since the term "yellows" carries the inference that a virus or bacterial disease is involved; also, because various shades of pink, red and purple, as well as yellow colors, are usually present. In general the symptoms observed on forage-crop legumes (clovers, peanuts, lespedeza, cowpeas, soybeans) include the common tip and marginal browning known as hopperburn on potatoes and eggplant, as well as conspicuous reddening, bronzing

and yellowing of leaves, petioles and stems. There is usually a pronounced dwarfing and curling of leaves, and a check in floral development. Symptoms vary somewhat on different host plants. Poos (1929) reported tests with 15 species of Homoptera, commonly found on forage crops in the field, upon a number of species of forage-crop plants in order to study the reaction of these plants to these insects. Only the potato leafhopper caused the typical injury, which was serious on alfalfa, red clover, white clover, nonpubescent soybean, peanut and sainfoin. Plants not too severely injured always recovered their normal condition when the insects were removed.

The amount of injury produced by *Empoasca fabae* was apparently directly proportional to the number of these insects present. A transfer of *E. fabae* from garden bean to alfalfa, from potato to alfalfa, from alfalfa to clover and vice versa, or from cowpeas to alfalfa, clover, and soybeans seemed to show no difference in the degree of the injurious symptoms or in the period of time required to produce them when these insects were again placed on seedlings of clover or alfalfa. In later work all attempts to induce immunity to the potato-leafhopper-injury in alfalfa and red clover were unsuccessful. No individual *E. fabae* was found which was unable to cause the injury. Granovsky's observation (1928) that the diseaselike symptoms were not systemic, at least not in the sense that many virus diseases of plants are, was confirmed. Poos and Wheeler (1934) showed that *E. fabae* inherited the ability to cause the typical diseaselike injury to its host plants.

The cause of the potato-leafhopper-injury has long been distinctly recognized as more than the mere removal of sap from the plants through the sucking mouthparts of the leafhopper. The theory that some chemical or enzymic toxin is injected into the plant (Granovsky 1930) is still held by some investigators although, apparently, no very definite experimental proof has been offered to support this theory. On the basis of studies of the feeding habits of six species of *Empoasca*, Smith and Poos (1931) found no evidence that a toxin was introduced into the plant by any of the species. These studies indicated that the injury by *Empoasca fabae* is the result of interference with translocation of plant materials which produce either wilting when xylem vessels are plugged by the sheath material through which the insect feeds, or yellowing or reddening when the phloem is disorganized and plugged.

Smith (1933) studied the nature of the sheath material in the feeding punctures produced by the potato leafhopper and by the three-cornered alfalfa hopper and concluded that this material is largely of insect origin and contains no plant substance, with the possible exception of pectose; also, that the highly insoluble sheath, persisting in the vascular tissue, probably interferes with the normal translocation of plant materials and accounts for the typical plant injuries caused by the feeding of *Empoasca fabae* and *Stictocephala festina*. Certain color tests for proteins and amino acids showed that the sheath material is largely proteinaceous. In a number of tests the sheath material responded similarly to tests on the chitinous exoskeleton. Johnson (1934) also studied the nature of the potato-leafhopper-injury to certain forage legumes and concluded that the injection of some toxic substance into the plant during the feeding of the leafhopper is improbable. He was able artificially to produce reddening and yellowing, almost identical with those caused by the feeding of *E. fabae*, by mechanically severing all but one of the vascular bundles in Ladino clover petioles and by girdling Ladino clover petioles and alfalfa stems by means of live steam. The chemical changes in leaves reddened and yellowed by artificial girdling and by the potato leafhopper are essentially the same.

The potato-leafhopper-injury to alfalfa from a practical standpoint (Poos & Johnson 1936) indicated losses in yield of alfalfa in cages ranging from 13.9 to 27 per cent during four seasons, 1929, 1931, 1932 and 1933. Data were obtained indicating that alfalfa moderately to severely injured during one season does not become entirely normal by the time the first cutting is made the following spring, the average reduction in yield being 17.6 per cent for the first cutting. Chemical analysis indicated that hay made from leafhopper-yellowed alfalfa

taken from leafhopper infested cages is lower in ash, protein, fat and possibly crude fiber than hay made from green alfalfa taken from cages kept free from leafhoppers. Johnson (1936) reported on the effect of potato-leafhopper-injury upon the carotene content of alfalfa and showed that the injured alfalfa contained approximately one-half as much carotene as was found in green alfalfa. It is, therefore, only about one-half as rich in potential vitamin A activity.

An important phase of the investigations on the potato-leafhopper-injury to forage-crop legumes is the proposal to control the insect through the use of resistant varieties of host plants. Pubescent varieties of alfalfa, red clover and soybeans were reported by Monteith and Hollowell (1929) to be more resistant to the potato-leafhopper-injury than the smooth or the appressed pubescent varieties. Studies on the choice of oviposition by the potato leafhopper and on the nymphal development of this species on different host plants were reported by Poos and Smith (1931) and indicated, in general, that the rough-hairy pubescent varieties, within a species, usually were much less injured by this insect than the non-pubescent or appressed pubescent varieties. It was shown that larger numbers of nymphs of *Empoasca fabae* hatched from certain hosts than from others regardless of whether such hosts were very hairy or only slightly pubescent.

In the case of red clover and soybeans, much smaller numbers of nymphs hatched from rough-hairy pubescent varieties than from the appressed pubescent or non-pubescent varieties with which they were compared. It should, however, not be concluded that the amount and type of pubescence on the various varieties of red clover and soybeans are the prime factors in determining the choice of host plants for oviposition by adults of *Empoasca fabae*, since this species deposited eggs freely in all of the host plants used, even when confined to varieties of a single species of plant which bore the different types and amounts of pubescence. It was also shown that the rough-hairy pubescence was not the principal factor in determining the percentage of nymphs which developed to adults, although this external physical characteristic may be correlated with one or more other factors possibly responsible for resistance to potato-leafhopper-injury.

Johnson and Hollowell (1935) studied soybean material of known genetic constitution and concluded from the material under test that resistance to potato-leafhopper-injury apparently is due to the rough-hairy pubescence, or to some character the inheritance of which is controlled by the same hereditary complex as pubescence, but no evidence of the existence of such a character was found.

PEANUTS

This crop is included as a forage crop because of the reliance placed upon it as forage for domestic animals in the Virginia-North Carolina peanut growing area where the writer, in cooperation with the Virginia Agricultural Experiment Station, has been investigating the potato-leafhopper-injury to peanuts during the past several seasons.

Ludwig (1921) in South Carolina was probably the first to report burning of peanut leaves, originating as a triangular yellowed area in the distal half of the leaflet. He reported this burning as associated with an attack of leafhoppers, possibly caused by them. Poos (1929, 1934) briefly described the diseaselike injury to peanuts caused by this leafhopper under field-cage conditions and illustrated both the effect on the foliage of the plants and on the yield of nuts. The common symptoms of this diseaselike injury were described as "burning of the tip and margin of the leaves and a dwarfing and yellowing of all of the vegetative parts with resultant reduction in floral development."

In 1937 this type of injury to peanuts in southeastern Virginia, during July and the early part of August, was very severe and very much resembled the "tipburn" or "hopperburn" of potato caused by the same species of leafhopper. Poos and Batten (1937) reported greatly increased yields as a result of attempts to control the potato leafhopper on peanuts.

Recently Metcalf (1937) gave the potato-leafhopper-injury on peanuts the name "pouts," which he states is caused by what may be termed the mass effect of toxins. No experimental evidence was submitted to support the toxin-injection

theory. The name "pouts," he states, was given to this disease by the farmers because they said the peanut plant was "pouting," and after it commenced to bloom it ceased to "pout." He considers this name very appropriate because he thinks plants usually recover about blooming time without further evidence of the injury.

Storey and Bottomley (1925) first reported the transmission of rosette of peanuts, or ground nuts as this crop is called in South Africa, by *Aphis laburni* Kalt. (*leguminosae* Theo.). This virus produces striking modifications in the peanut plants, which are manifested by various types of symptoms. According to Storey (1935b) it was first recognized in Tanganyika and since has been found to be present in tropical and southern Africa wherever peanuts are grown. All varieties are susceptible.

Hargreaves (1936a) reported that peanuts on lightly shaded plots were not affected so early or so severely by this mosaic disease as those in the open, probably because the ants which attend the aphid vector prefer the open. Only the rosette type of mosaic disease seriously affects the yield, and if infection occurs after the plant is about half grown there is apparently little reduction. It was found that the aphids retained the power of infection after molting. Hargreaves (1936b) found *Aphis laburni* occurring on cowpea, and typical symptoms of the disease were produced on this host by aphids infected with the peanut mosaic virus.

CLOVERS

Dickson (1922) reported using the pea aphid, *Macrosiphum pisi* Kalt., as the agent of inoculation in transferring the virus of mosaic disease of red clover (*Trifolium pratense*). Successful results were reported in the transmission of this virus to healthy red clover, alsike clover (*T. hybridum*), white clover (*T. repens*), crimson clover (*T. incarnatum*) and hop clover (*Medicago lupulina*). Negative results were obtained with white sweetclover (*Melilotus alba*) and yellow sweetclover (*M. officinalis*). In one instance the same aphids from red clover infected a plant of alfalfa (*Medicago sativa*).

Doolittle and Jones (1925) reported transmitting mosaic from red clover to the garden pea and vice versa by means of the pea aphid. Inoculations by means of aphids also indicated that red clover is susceptible to mosaic of sweet pea. Red clover was considered the overwintering host of pea mosaic by these writers.

Van der Meulen (1928) reported that *Myzus persicae* (Sulz.), *Aphis rhamni* Boyer and *Macrosiphum pisi* Kalt. transmitted mosaic of white clover; also, that *A. rhamni* transmitted this mosaic of white clover to potato.

From their cross-inoculation experiments Zaumeyer and Wade (1935) reported that the viruses causing the mosaic disease of alsike clover, white sweetclover, yellow sweetclover, white clover and alfalfa are all transmissible to beans, whereas the virus producing mosaic in red clover is not. These authors conclude that it is possible that beans may become infected from the various legume mosaic viruses in the field as a result of transmission by several species of aphids, and recommend that bean fields be located as far from infected commercial clover plantings as possible. They also suggest the elimination of legumes growing wild along roadways, fence rows and irrigation ditches as a possible effective control measure.

Wingard (1928) has shown that yellow sweetclover and black-eye cowpea (*Vigna sinensis* Endl.) are susceptible to tobacco ringspot virus, for which apparently no insect vector has been reported. Kenneth M. Smith (1932) has shown that the broad bean (*Vicia faba* L.) and the cultivated lupine are susceptible to infection with the virus of tomato spotted wilt transmitted by *Thrips tabaci* Lind. Black (1936), reporting on some insect and host relationships of the potato yellow dwarf virus, apparently in New York, stated that the clover leafhopper, *Aceratagallia sanguinolenta* (Prov.), is a vector of this virus; also, that red clover is susceptible to the virus and that viruliferous insects have been collected from clover fields.

Osborn (1937) described a vein-mosaic virus of red clover which he transmitted from red clover to *Vicia faba*, sweet pea, red clover, white clover, alsike clover and crimson clover by means of the pea aphid. He also transmitted it by mechanical means to the same hosts (except sweet pea) and, in addition, to white sweetclover and several varieties of garden pea. Transmission was not obtained with the

potato aphid *Macrosiphum gei* (Koch), and the bean aphid, *Aphis rumicis* L.

From these various reports it seems evident that the need for control of mosaic diseases of the clovers may be of economic importance more because the clovers serve as alternate hosts or "reservoirs" for the overwintering of a numberof viruses destructive to other crops than because of the losses inflicted upon the clovers themselves.

VARIOUS HOST PLANTS

Other diseases or diseaselike injuries, of less importance perhaps as transmitted or caused by insects, of cereal and forage crops are mentioned here, although not frequently treated in the literature. From experimental evidence obtained during 1921–23, C. E. Smith (1924) demonstrated that the bean leaf beetle, *Cerotoma trifurcata* (Forst.), is a definite and efficient carrier of cowpea mosaic, a serious disease of cowpeas, causing mottling and crinkling of leaves. The other insects tested as vectors, the southern green stinkbug, *Nezara viridula* (L.), and the three-cornered alfalfa hopper, *Stictocephala festina*, yielded only negative results. Elmer (1922) reported on mosaic cross-inoculation and insect-transmission studies, which showed that aphids (species undetermined) and a mealybug, *Dactylopius* sp., transmit the mosaic from diseased to healthy seedling cowpea plants. Cross-inoculation experiments showed that mealybugs transferred mosaic from *Solanum* and cucurbit plants to healthy cowpea seedlings, from cowpea to soybean plants, and from crookneck squash and eggplant to cowpea seedlings. Aphids transmitted the disease from potato to cowpea seedlings.

Wadley (1929) reported observations on the injury caused by the green bug, *Toxoptera graminum* Rond., to wheat in Minnesota and concluded that the secretion of a chlorophyll-destroying enzyme may contribute largely to the economic importance of this aphid.

Granovsky and Levine (1932) reported on the dissemination of cereal rust spores in the greenhouse by terrestrial invertebrates and found that plant lice, thrips, fungous gnats and other insects in feeding also come into intimate contact with the pustules of rusted plants and are found to carry rust spores on their bodies, thus serving as vectors.

Manninger and Manninger (1933) reported that young shoots of wheat in Hungary died early in spring as a result of the feeding by three species of pentatomid bugs, viz., *Eurygaster austriaca* Schr., *E. maura* L., and *Aelia acuminata* L., which they thought probably introduced a proteolytic enzyme into the plants, many of which were killed and turned white. The quality of the wheat and of the flour from infested plants was depreciated owing to the feeding of the bugs on the milky grains, even when only 5 per cent of these were punctured.

Osborn (1935, 1937), in his work on pea viruses, used the broad bean, for the reason that it is highly susceptible to pea viruses, grows rapidly, serves as a satisfactory food for the aphids and facilitates transfer of large colonies because of its broad smooth leaves. The pea-mosaic disease used in his experiments was obtained from a naturally infected broad bean plant growing in a field near Princeton, N. J.

Much has been written regarding a disease known as white ear, "silvertop" or "whitetop," but the reports are so conflicting and cover such a large volume of literature that it seems inadvisable to attempt to refer definitely to any of these references here. The injury has been reported as a disease on many species of both grains and grasses in various countries, and its cause has been ascribed by different workers to various factors. Some writers definitely name certain species of insects as being carriers of the disease or as being responsible for a more or less direct injury, whereas other writers are positive that insects are not responsible for all of the symptoms. Some of the insects and related forms named as being definitely responsible for losses occasioned by this disease are thrips, mites, frit flies, leafhoppers, capsids, cercopids, cecidomyiids and caterpillars. In view of the wide discrepancy of opinion as to the cause of white ear of grains and grasses, it would appear to be a good subject for further investigation.—1-6-38.

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Discussion of Symposium Paper by F. W. Poos

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Dr. Poos has ably presented a summary of findings in the field of insect relationship to diseases of cereal and forage crops. I wish to thank him, in behalf of all interested in this type of research, for a paper the preparation of which must have required a great deal of tedious effort in sifting the large volume of literature on the subject and presenting it in this concise form.

As indicated by Dr. Poos, the field of insect relationship to diseases has not received the proportionate study which its importance has warranted, when compared with research on insects causing direct injury. This to-be-expected course of events, with first emphasis being placed upon the more immediately apparent injury, has left untouched many phases of the relationship between insects and plant diseases. Only a small beginning has been made in this field and it therefore appears to offer greater opportunities for addition to scientific knowledge and for increasing the production efficiency in the crops involved than does the older field of direct injury studies.

Time does not permit discussion of the various findings in insect-disease complexes in cereal and forage crops that were brought out, but some remarks will be made on findings in the crops most familiar to me.

CEREAL CROPS.—I was especially interested in the discussion of insects and their relationship to diseases of rice. Although dwarf disease is not known to occur in the United States, there exists an insect-disease complex known as pecky rice which causes heavy losses through the production of chalky, distorted and discolored kernels. It is produced partially by the stinkbug, *Solubea pugnax* (F.), in sucking out a portion of the contents of the rice glume, and partially by various disease organisms entering through the puncture. Pecky rice may also result from direct attack by the disease organisms on the developing grain, in the absence of insect injury. Douglas, Tullis & Ryker have all made important findings in pecky rice studies.

An apparently somewhat similar type of injury was recently reported as occurring on wheat in German Silesia by Nitsche & Mayer. Any observations on this type of injury on wheat in America would be of interest.

The insect transmission of corn diseases merits much attention owing to the fact that this crop is widely grown and to the possible interrelationship of its diseases with those of sugarcane, other cultivated and wild grasses, and even with those of non-grasses, as in the case of celery mosaic. Findings on streak and bacterial wilt diseases of corn reveal the possibilities in and the need of increased studies on other insect-disease problems. The overwintering of the bacterial wilt organism in the body of the vector presents interesting possibilities for reducing disease prevalence by vector control.

SUGARCANE.—Insects have been shown to be definitely involved in the spread of all of the more important diseases affecting sugarcane in the United States.

Root rot caused by various species of *Pythium* is known to gain entrance to plant tissue through wounds caused by such small animals as the snail *Zonitoides arboreus* (Say), the symphylid *Hanseniella unguiculata* (Hansen), and two species of springtails.

In standing sugarcane and in canes planted for seed the amount of red rot, *Colletotrichum falcatum*, tends to vary in direct proportion to the amount of infestation by the sugarcane borer, *Diatraea saccharalis* (F.). Red rot gains entrance

through and follows up the tunnels caused by this insect. In ratoon cane, red rot follows intury by the small weevil, *Anacentrinus* sp. In young cane shoots, the entrance of red rot often prevents the plant from suckering out following sugarcane beetle injury. The most complex and therefore one of the most intriguing associations of insects with sugarcane diseases in the United States is that with mosaic. In 1930 this problem was thought to have reached more or less of a standstill throughout the world with one strain of mosaic disease of sugarcane and *Aphis maidis* Fitch as its sole vector. Since that time, however, several strains of mosaic have been distinguished, and three additional aphids have been found to transfer the disease. These discoveries have served to reopen and vastly complicate the problem of insect relationship to sugarcane mosaic.

The amount of sugarcane mosaic spread in a given field is apparently dependent upon three factors, the number and species of vectors present, the species and abundance of alternate hosts of insects and mosaic and the strain or strains of mosaic present. It is known that in Louisiana the relative populations of the three commonly found vectors vary widely, that each may be the major vector in a certain locality and that each may be of little or no importance in another locality. It also seems possible that some heretofore unproved but very numerous vector may be the major agent of mosaic spread in some fields, although it may possess a low degree of efficiency in mosaic transfer.

The presence of mosaic-susceptible wild grasses in a cane field apparently results in an increase in mosaic spread. It also appears that the presence of certain preferred host grasses which have not been found susceptible to mosaic, coupled with the absence of mosaic-susceptible grasses, may result in a decrease in mosaic spread.

Pathologists have found that different strains of mosaic occur in different sections of Louisiana, and that some of these strains may be more readily transferred than others by artificial means. It seems likely that some of these strains may be more readily transferred than others by any given vector.

FUTURE POSSIBILITIES.—It is evident from the previous discussion on leguminous crops that it is difficult to distinguish between injury resulting respectively from disease organisms, insect attack and physiological conditions. Additional investigations would probably reveal new examples of insect relationship.

Interesting possibilities for disease control reside in the development of insect-resistant or insect-tolerant crop varieties, the growing of insect-preferred but disease-immune host plants in and/or around fields of the susceptible crop, the growing of the susceptible crop in areas supporting a minimum of viruliferous vectors, the use of insect repellents on disease-susceptible crops and the direct control of insect vectors.—1-14-38.

Problems Involved in Control of Plant Diseases and Insects

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As general propositions, valid in the control of plant diseases and insect pests alike, I wish to present for your consideration the theses that control measures should be joint; economically sound, interstate or international in some cases; at any rate, based on real international research; that in seeking for economical control of plant pests, we should not limit ourselves to a few well tried and conventional methods; that to plan efficient control we need more information on "unimportant" fungi and insects; that prevention is better than control; and that prevention should include the avoidance of areas known to be seriously subject to pests for which we have as yet no proved economical control methods.

CONTROL A JOINT MATTER.—The attack must be on all fronts. That is, it must be joint. Whatever administrative or other reasons there may be for keeping plant pathology and entomology separate in our teaching and study, no such distinction is practicable in field work. Recommendations for the control of disease must always take into consideration the insects likely to be present and the control meas-

ures being recommended for them. I still resent, although it happened more than twenty years ago, the remark of a prominent plant pathologist, that it wasn't his job to worry about the control of a disease once it was proved to be insect borne. That this was for a generation the official attitude and personal opinion of American plant pathologists, I admit. That it was a mistake, I sincerely believe.

From the viewpoint of the grower, which should be ours in the field, such a disease as false blossom of the cranberry will not be controlled unless, or until, we have an adequate control for the leafhopper that carries the disease, and have educated growers in the use of that method. As this last remark suggests, I consider extension work an integral part of plant disease control. If the attainment of this end means that our so-called research men must do some extension work, they may well be the gainers. I quite agree with Brierly that "The man who possesses that constructive vision and luminous quality of mind which fits him to carry out whole-time research fruitfully for more than a limited period is a very rare man indeed."

CONTROL METHODS ECONOMICALLY PRACTICAL.—Outside the field of ornamentals, control should cost demonstrably less than the probable losses from the disease. However much we may enjoy experimenting with seemingly impracticable problems and solutions, we owe it to our profession not to urge the use of any control method unless it meets this economic test. To make this possible, we should have a much more accurate idea what disease and insect losses actually cost. Some of the "dollar" estimates of losses from plant diseases and insects published 20 years ago were little short of fantastic and did us very little good with the public or our colleagues in other fields of biology. Many of you have read, as I believe every one interested in the commercial control of plant pests should read, at least the first 60 pages of Bulletin 553 of the California Experiment Station. You will find some of the main conclusions summarized in the June, 1937, number of the *Botanical Review*, pages 301 to 305. Whether you agree with these conclusions or not, they are stimulating and thought-provoking.

This fall I listened while two of the recognized leaders in the field discussed the control of apple pests in the Middle West. If I remember correctly, one of their spray schedules involved nine applications, and there was some additional expense for removing the spray residue afterward. One of these men remarked that this year, at least, he would rather have the check for the spray material in some orchards than the check for the crop. Under the circumstances, isn't it about time to re-examine not merely our spray schedules, but the whole question of whether spraying for 100 per cent disease control is actually sound business practice and good sense?

A year or two ago I asked a plant pathologist who had spent several years in the study of the control of damping-off in forest nurseries for a statement of his recommendations. His first sentence was "If your loss is less than 15 per cent, forget it." I think it would be an excellent practice and would greatly tend to establish us in the eyes of practical men if all of our recommendations for disease control began, "If your loss is less than — per cent, forget it." The figure to be inserted in the blank would have to be determined separately for every disease or insect and for each control measure. In order to determine what the figure should be, we need much more information regarding crop losses from both insects and crop diseases.

CONTROL MEASURES SOMETIMES INTERSTATE.—It is becoming increasingly evident that for greatest efficiency disease control frequently should *not* begin at home. There is, I am told, much evidence to indicate that if stem rust of wheat could be greatly reduced in Mexico and the Southwest, the losses in the Great Plains and in Canada would be greatly reduced also, and that, without such a change in the southern regions, we will never be free of the threat of epidemics.

Having watched the behavior of downy mildew of tobacco in the United States since 1931, I am of the opinion, though at least one investigator whose judgment I value very highly disagrees with me, that if the disease could be eliminated, perhaps even greatly reduced in Florida and Georgia, it might never attain importance in the states farther north.

DISEASE AND INSECT CONTROL INTERNATIONAL.—I do not here refer to inspec-

tion or quarantine matters. I know very little about them. It would seem to be axiomatic, however, that quarantine administration is a matter for both entomologists and plant pathologists, that the detection of diseases in imported material is even more difficult than the detection of insects and consequently that inspectors should be even more adequately trained in plant pathology than in entomology. If you are interested in quarantine matters, I recommend to your careful consideration the thoughtful and stimulating paper by H. T. Gussow, "Plant Quarantine Legislation—A review and a reform," published in *Phytopathology*, Volume 26, pages 465–482, 1936.

Probably we are agreed that in spite of all precautions, some pests may some time enter any country. In order to be prepared for effectively dealing with the diseases and insect pests which we may receive from foreign countries, we need more work in those countries and work of a wholly different type. For cultivated crops common to many regions, it has been of value to send investigators familiar with these crops from one country to another.

For forest trees, the ones in which introduced diseases have been most serious, I suspect such expeditions would be of little value. I spent three years studying the chestnut blight fungus and its relatives. I remember the difficulty the Anderson brothers had in distinguishing the imported parasite from the widely scattered native saprophyte. I remember, also, the reluctance with which some investigators accepted their sound conclusions. It is my opinion that if, during the years 1900–1904, the United States had sent to Asia the five most competent American students of tree diseases and tree fungi, none of them would have brought back any hint of the impending extermination of the American chestnut. I suspect that the total "Endothia" result of this imaginary expedition would have been a half dozen specimens of an inconspicuous fungus on chestnut, probably labelled *Endothia radicalis* variety *chinensis*.

The only sure, or rather the most nearly sure, method of getting some indication of what the forest fungi or forest insects of foreign countries are likely to do here is to establish in those countries plantings —real man-sized forest plantings—of our species in those countries and there study them. Of course, there would still remain the uncertainty of differences in climate, but we could at least test our native species in the presence of the foreign insects or diseases. This idea is not original with me. Like most people, I borrow many of my best ideas.

THE "CHILD LABOR" PROBLEM IN RESEARCH.—While I am engaged in expounding borrowed ideas, I may as well pass on one not wholly unrelated to the one assigned, which has come to me this summer from two independent sources. In the course of separate conversations this summer, a well known state entomologist and a plant pathologist engaged in full-time research volunteered the suggestion that one reason some of the more difficult problems of plant disease control were not tackled more aggressively was that they did not make good "student problems." It appears that, in the opinion of these gentlemen, there is a tendency on the part of those directing research to seek for their students problems in which they can practically guarantee results. The students are naturally enough anxious to get their credits as soon as they can in the easiest possible manner. I have no personal contacts with the fellowships which are so popular nowadays, but I wonder if they do not hold out temptations of a similar nature.

If the amount of money which is now handed out in part-time fellowships and scholarships were put into research handled by grown men, there might be fewer Ph.D's in the spring crop. On the other hand, there might be a somewhat higher average of honest-to-goodness research on man-sized problems. Meanwhile the students could be sharpening their teeth or their wits on problems the solution of which do not relate directly to someone's livelihood. The reply that would no doubt be made to this suggestion is that administrative offices are now demanding, in their specifications for jobs, students trained in the particular organ of the particular host in the particular locality which they hope to investigate. Conceivably, however, we could educate administrative officers to a somewhat broader viewpoint.

"UNCONVENTIONAL" CONTROL METHODS.—If plant pest control was a game or

even a professional wrestling match, we might take pride in sticking so closely to the established rules. Actually, I believe we handicap ourselves in our search for means of controlling diseases and insects by an excessive conservatism. Twenty years ago plant pathologists were justly, if contemptuously, referred to as "squirt-gun botanists," because, as a control for any disease for any crop, they suggested, almost as one would chant a refrain, "Spray with Bordeaux mixture." I believe I am correct in saying that entomologists rarely considered the possibility of substitutes for arsenate of lead until forced to by legislation of which many of them did not wholly approve.

This conservatism, which in this case is only another name for complacency, is of course not peculiar to plant pathologists and is encouraged by the applied phases of our work. In reading, this fall, the recently published *Story of Human Error* I came across this sentence regarding the history of medicine, page 390: "The usual and hence normal state of medicine has been one of almost complete stagnation and complacency." If we are to avoid a similar fate we must be ready to re-examine our control methods at any time and not put aside, without actual test, any suggestion of any sort.

Some of you remember the ill-advised mirth which greeted Kunkel's suggestion in 1929 that aster yellows be controlled by fencing out the leafhoppers which carried the disease. Well, what better, simpler, cheaper or more sensible method could be suggested? At any rate, practical gardeners had no objection to adopting it.

Eddins has devised a very unconventional but exceedingly effective control for brown rot of potatoes in Florida which consists in applying sulfur after the crop is harvested, thus changing the acidity of the soil so much that the bacteria are killed in two or three months, then applying lime and raising a largely disease-free potato crop.

Baines tells me that the apple growers of Indiana long ago found that collar rot of Grimes caused by *Phytophthora cactorum* could be avoided by "double working," that is, grafting a stock of Northwestern Greening, for example, on to the crab roots and then grafting the Grimes on this 16 or 18 inches above, thus giving the desired but susceptible variety a sturdy and resistant trunk. These are only samples. Other means will occur to you, both now and in the field next summer.

POTENTIAL PESTS.—That almost any fungus or insect is worthy of study as a "potential pest" is too true to be argued and too rarely acted upon. No family of insects or fungi is of such character that it can furnish a guarantee of good behavior for all its members. I used to hear it argued 25 years ago that there was little likelihood of the chestnut bark fungus being as serious as Metcalf said it was, because no closely related species had shown such tendencies. I understand that the Mexican bean beetle, surely a serious pest, belongs to the generally highly beneficial family of lady bug beetles.

When, in the summer of 1933, I went to Massachusetts to assist in the first search there for the Dutch elm disease, I was much surprised that none of the excellent scientific institutions of that state had any significant records of the range of the insect known to carry the disease. Everybody knew that it had been discovered in Cambridge 25 or 30 years earlier and that was about all.

G. F. Knowlton ("The insect fauna of Utah"—from the standpoint of an economic entomologist. Utah Acad. Sci. Proc. **13**: 249–262, 1936) calls attention to the fact that "when the potato psyllid was found by Dr. B. L. Richards and his associates to be the cause of an apparently undescribed and recently developed disease of potatoes, now called 'psyllid yellows,' almost nothing was known at the time concerning the distribution of this insect in Utah except that it had been recorded from two localities in the state."

He adds that, "Had a policy of collecting, identifying and recording insects from various host plants and localities of the state been in general effect, much knowledge concerning this species, its distribution and host plants might have been immediately available in the files and insect collection of the Utah Agricultural Experiment Station. Because of lack of such information, several years of study and considerable expense have been

required to carry on a general survey of the range of this pest in Utah, to determine a reasonable number of the plants upon which it breeds and to secure information concerning other seasonable hosts upon which it merely feeds."

PREVENTION BETTER THAN TREATMENT.—In their zeal for demonstrating their ability to solve difficult problems of disease control, plant pathologists seem a little like the old time volunteer firemen who were more interested in beating the other outfit to the fire and putting on a good show there than in saving the building. Pathologists seem sometimes to forget that the real purpose of agriculture is not to control plant diseases but to grow profitable crops. For growing profitable crops, disease prevention is often better than disease treatment.

First of all, in this category come selection and breeding. It is pleasant to note that after a generation of ridiculing the idea, American entomologists have at last entered into the field of breeding for insect resistance with all the enthusiasm of recent converts.

There is another type of disease and insect loss prevention, the aggressive adoption of which seems to me long overdue in the United States. In advocating it I frankly part company with some very good friends of mine who are among the leaders of our profession in America. I refer to an attempt to discourage the planting of specific crops in areas of known excessive disease hazard.

Last summer my attention was called to a paper by Young and Baughman in the *Monthly Weather Review* for May, 1936, entitled, "Temperature survey of Kittitas County, Washington." This details the results of a five-year temperature survey of a region which was being opened to farming through irrigation by the United States Reclamation Service. The preface contains the common sense statement that it was "decided to take all possible steps to insure the success of the individual farmer in taking up land under the new project." The purpose of the survey was obviously to protect the prospective orchardists against unnecessary frost hazards. What could be more sensible?

But if there are valid reasons for soil surveys and frost surveys to determine the probable limits of safe farming, why not protective or prospective plant pest surveys as well? Such surveys might well serve to discourage ill-advised and unnecessary expansion. Most of you can recall instances of the promotion of new (usually specialized) crops in certain farming areas, which shortly proved to be wholly unsuited for these regions, frequently because the diseases could not be controlled. Too often the information was already in the hands of pathologists or entomologists which, if made available and followed, would have prevented these costly and disastrous attempts.

To cite a few examples in the field which was for fifteen years my special interest, that is, small fruit diseases: information as to the probable difficulty of disease control was already in the hands of plant pathologists which, if it could have been followed by growers, would have prevented costly and disastrous attempts to grow Vinifera grapes in Texas, Euvitis grapes in Florida and the coastal regions of the Carolinas, raspberries in eastern South Carolina, currants in eastern Maryland and cranberries in extreme southern New Jersey. In October, 1931, I had a letter from V. H. Young of Arkansas calling my attention to a promotion of raspberry plantings involving some hundreds of acres, entered into without consulting the experiment station people, which was in very serious trouble from disease.

Material for the compilation by plant pathologists and entomologists of a plant pest hazard map of the United States is at least partly in hand already. One of my last official acts in the Plant Disease Survey was to request, from pathologists in various states, reports of instances in which entire crop projects had failed because of plant diseases for which no adequate means of control was known. The reports received were published in Volume 18 of the *Plant Disease Reporter* beginning with the March 15 number and continuing in those for April 1 and May 1. They make illuminating, if somewhat depressing, reading. Even in disease control the saddest words still are, "it might have been." My limited acquaintance with the literature of economic entomology leads me to believe that even more information is in the hands of entomologists. A paper

which may profitably be read in this connection is, "The beet leafhopper in the central Columbia River breeding area," by Orin A. Hills, Journal of Agricultural Research **55**: 21–31, July 1, 1937.

The preparation, or at least a crude beginning, of maps of regions extra hazardous because of unusual risks from crop pests would seem to be, as already said, well within our scientific possibilities; whether within our psychological possibilities is quite another matter. It admittedly runs counter to most of our previous practice as well as to our American psychology. I have twice ventured to present this idea to my associates in the American Phytopathological Society, once at an informal meeting in Atlantic City in 1931 and once through the pages of *Phytopathology*. Both attempts were greeted with enthusiastic, although not quite unanimous, disapproval. Why then do I try a third time? Well, I hope no one will be tempted to invidious comparisons if I quote in this connection a sentence from the final chapter, page 296, of the sixth and last English edition of Darwin's *Origin of Species:* "A few naturalists, endowed with much flexibility of mind, . . . may be influenced by this volume; but I look with confidence to the future—to young and rising naturalists, who will be able to view both sides of the question with impartiality."—1-4-38.

The Laboratory Rearing of Flesh Flies and the Relations Between Temperature, Diet and Egg Production*

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The fact that several species of flesh flies can be reared throughout the year under laboratory conditions with relatively simple equipment has caused many investigators to use them as experimental animals. In this laboratory the larvae have been used in experiments on nutritional requirements and on reactions to light. The adults are being used in testing repellants and attractants and with light traps. They have been employed in other laboratories in rearing parasites, in experimental pollination of plants and for the treatment of osteomyelitis. In connection with the latter work it was highly desirable that the larvae be reared on sterile food, and hence numerous papers have been published which have established that certain sterile larval diets are adequate and satisfactory (Frew 1928, Baer 1931, Hobson 1932, Causey 1932, Michelbacher, *et al.* 1932).

For most purposes, however, such precautions are unnecessary, and difficulties have arisen only when large numbers of insects are needed continuously over long periods. *Lucilia sericata* has been reared in the Division of Entomology without interruption for eight years. In the beginning the earlier experience of Herms (1907) was a great help. The purpose of the present paper is to outline the technique which has been evolved, including information concerning certain new or disputed observations on the necessary conditions for the production of fertile eggs.

REARING CHAMBER.—The rearing chamber is a rectangular box approximately 5 by 5 by 7 feet high that stands in the northeast corner of the laboratory, which has a blank wall on the east and a large window on the north. The three sides of this chamber are of glass and the ceiling is solid boards. The floor is the ordinary laboratory linoleum. A standard size glass door is in the southwest corner. Beneath the laboratory window and near the floor is a square opening 12 by 12 inches covered with wire screen. In the opposite corner near the ceiling is a screened opening leading into a stove pipe that connects with a ventilator duct. A small fan set before the upper opening causes a circulation within the rearing chamber as well as a slow but steady passage of air through it. Since the inlet hole is near a window which is ordinarily partly open, the incoming air is not very different from the outside atmosphere. Three shelves 2 feet wide are set at even

* Contribution from the laboratory of insect physiology and toxicology, Division of Entomology and Parasitology, University of California.

intervals on the walls opposite the door. The entire interior except the glass and the floor is painted with white gloss enamel.

The temperature ordinarily is maintained at $25 \pm 1°$ C. by means of a Hetlite heating coil connected with a bimetallic circuit breaker. When more accurate control is needed a mercury regulator is employed. (Unless noted otherwise all temperatures are given in degrees Centigrade.)

As will be mentioned later, humidity control of the whole chamber is not of much importance, but a can of water is kept over the heating unit and the relative humidity is about 60 per cent in winter and somewhat lower in summer when the heater is on less of the time. A 60-watt electric light is located near the center of the ceiling but is ordinarily not turned on at night. Other portable lights with reflectors are used as needed, e.g., in transferring adult flies.

REARING PROCEDURE: ADULTS.—The method of handling *Lucilia sericata* throughout the life cycle will be outlined, starting with the adult stage. Several hundred flies, either laboratory bred or wild, are placed in white enameled wooden cages 12 inches wide, 24 inches long and 9 inches high. The front is covered with cheesecloth, and there is a 5 inch hole in the back with a sleeve attached. All transferring of adults is done by taking advantage of their positive photo and negative geotropisms, e.g., the container from which they are to be removed is darkened and the desired new container is set on top and strongly illuminated. All cages for adult flies are provided with holes in the top and bottom about $1\frac{1}{4}$ inches in diameter which are ordinarily plugged with corks but are opened and set together during transferring of flies. Passage through the small hole is slow enough so that accurate counts can be made if desired.

The adults are provided with water by means of a closed water jar with exposed cotton wick. Contamination is largely prevented, and the flies cannot drown as they do in an open vessel. Cube sugar in a Petri dish or other shallow container is provided at all times. This source of carbohydrate is entirely adequate nutritionally and, as mentioned by Haub & Miller (1932), it is much easier to use than honey, syrup, fruits or granulated sugar. Since the flies consume sugar and water alternately it is advisable to place the containers close together.

The protein needed for egg formation is supplied by fish heads. Halibut is often used but other kinds seem equally satisfactory. A point of considerable economic importance is that fish heads may be obtained free of charge, whereas lean meat which Haub & Miller (1932) prefer is expensive in the quantities needed for extensive fly rearing.

As soon as enough flies have emerged to stock a cage a fish head is placed therein on a Petri dish and left for 24 hours. This is usually repeated on the second or third day. At any time after the tenth day, eggs are laid whenever a head is placed in the cage.

REARING PROCEDURE: EGGS.—Many different kinds of flesh have been found to be acceptable to the female flies for egg laying. Fish heads are particularly suitable because of the moist cavities and channels within them, which seem to be attractive to the flies and which prevent desiccation of the eggs. Preferably they should be fresh fish but no objection has been found to heads that have been kept at 0° F. for several weeks. However, prolonged freezing causes rapid softening of the tissues when they are thawed and the physical condition is not entirely suitable for subsequent larval feeding. Dry meat is distinctly less attractive to the adults and putrid meat is usually avoided entirely.

If egg laying does not begin soon after a fish head in the proper condition has been introduced it can be brought about in nearly all cases by greater light intensity, e.g., by placing the cage in strong sunshine or by putting an electric light nearby. The eggs are laid in batches and the number that will be laid at a time is widely variable, but inspection of the heads occasionally seems to disturb the flies only momentarily and with a little practice the total number of eggs can be estimated with fair accuracy. It is thus possible to take only as many eggs as are desired. This is a point of considerable importance, for the females are able to retain eggs over long periods, and by proper management the output of a given number of flies may be used to the utmost advantage.

REARING PROCEDURE: LARVAE.—In agreement with the results of Wardle (1930) the eggs were found to hatch at 25° in approximately 12 hours. Within the crevices of fish heads the eggs remain moist so there is little danger of any deleterious effects from desiccation, which has been observed when eggs are laid on the surface of beef.

The ratio of number of larvae to amount of fish has much to do with the success of the whole procedure, for if acceptable food is not constantly before them the larvae will scatter in all directions and if too much is provided at a time it will putrefy and have toxic or fatal effects. Experience has shown that for 1000 eggs a very few grams of fish are sufficient for the first 24 hours of larval growth. A small fish head (about 100 grams) is required for the second day, and a large one (about 200 grams) for each of the two following days. Feeding then ceases except for a few retarded larvae which for an unknown reason sometimes occur. Allowing for the fact that fish heads are far from entirely edible the amounts mentioned agree fairly well with the observation of Salt (1932) that 67 *Lucilia sericata* larvae can be amply nourished on 10 grams of lean beef.

The eggs and fish are placed together in wide-mouth, pint Mason jars containing one-half inch of sand which soaks up liquid as it is liberated. Any handling of the eggs should always be done with moistened tools to avoid tearing the covering. At least 500 larvae can be reared per jar. Each pint culture vessel is placed within a one gallon battery jar which has an inch of sand on the bottom.

Proper ventilation is a matter of considerable importance, for a non-sterile culture in a closed vessel soon becomes unfavorable for the larvae. They attempt to leave and if unable to get out may become motionless and apparently dead. The toxic condition is caused by some volatile material for if the vessel is opened at any time within several hours after the symptoms appear the larvae soon recover, but prolonged confinement is invariably fatal. It is possible that the condition is due to the ammonia that is produced in abundance, for similar anesthetic effects are caused by that gas. Adequate ventilation is easily secured if the outer battery jars are covered with only a single thickness of bobbinet which allows circulation and also prevents any adults that may be in the rearing chamber from depositing eggs on the larval food. It is useless to put several layers of cloth over the jars as a precaution against the larvae escaping for they can make their way through unbelievably small holes. No special precautions about light are necessary but strong illumination upon the larvae is undesirable because it prompts them to wander all over the vessel instead of feeding steadily.

When fully fed (requiring a little over 3 days at 25°) the larvae leave the inner jar and migrate to the sand in the outer one to pupate. To ensure that they do not pupate within the culture vessel, the sand in it may be moistened on the third day if any part of it is still dry. If considerable numbers of larvae leave the inner jar before feeding is completed, because of insufficient food, they tend to remain upon the sand in the outer vessel and may be baited by a piece of fish and returned to the culture vessel.

While excess moisture inhibits pupation (Cousin, 1929d) it is also true that larvae will not pupate in very dry sand. Hence if they are observed to wander around in the outer vessel a little water should be sprinkled upon the sand. Cousin (1929e) and Brown (1936) have noted previously that dryness may delay or prevent pupation. The observations of Cousin (1929d) and of Wardle (1930) that there is an optimum humidity for pupation are undoubtedly correct but *Lucilia sericata* can tolerate a wide range of conditions. For example, pupation and emergence have occurred many times in wads of cotton which were soaked with water, and dry pill boxes set on a laboratory table are entirely suitable.

The chief reason the larvae leave the culture vessel at the conclusion of feeding seems to be their reluctance to pupate in or near the products of digestion and decomposition. The observation of Haddow & Thomson (1937) that earth or sand are unfavorable for pupation because they become compacted about the pupae does not seem to apply to the sand used. It contains but little fine material and all passes through an ordinary kitchen strainer of 14 meshes to the inch.

REARING PROCEDURE: PUPAE.—When the fully grown larvae have left the pint

jars these are removed and the battery jars are covered with longcloth held tightly by a rubber band to prevent parasitism by the Pteromalid, *Mormoniella vitripennis*. Experiments have shown that eggs of the parasite are laid within the newly formed pupae but not within the larvae or prepupae (see also Cousin, 1933). Hence it is necessary only to provide plenty of sand for the larvae to burrow into before pupation and to cover the jars so that any pupae which chance to remain above the sand cannot be attacked. If an infestation does occur it is still possible to use the unparasitized pupae, for flies will emerge from them in about eight days, whereas the parasites do not begin to emerge until 10 to 12 days. Hence, an infestation can be eliminated by proper handling without seriously interrupting fly rearing. When flies emerge from a large mass of pupae in the absence of sand there is a serious mortality of pupae, apparently caused by the liquid which is set free during the first emergences.

The emergence from a group that was uniformly nourished as larvae is usually complete within two days. The flies require no food during this time but readily accept water, which should be put into the jar before emergence begins. Transference to a regular breeding cage is made either through the small hole in the bottom or the large hole in the back, the cover of the jar being slipped off after the box is placed above it. Adults are photonegative until their cuticle has darkened; so it is not possible to handle them by darkening the jar and illuminating the cage above until about two hours after emergence. Once a group of flies is established in a cage, a feeding procedure is started, as outlined above under the rearing procedure for adults.

If for any reason it is desired to remove pupae from the sand this is done by gently shaking the mixture in the kitchen strainer mentioned above, which passes the sand but retains the pupae. Such pupae may be put directly into a breeding cage before emergence, but in that case they should be scattered on a paper towel to avoid soaking with liquid during emergence.

INTERRUPTION OF LIFE CYCLE.—The different stages of *Lucilia sericata* may be stored at low temperature with varying success. This may be necessary when extraordinary numbers of any stage are needed at one time. Eggs may be held at 10° for 48 hours with no appreciable mortality if the humidity is high but, as also found by Miller, Doan & Wilson (1932), 72 hours results in very poor hatching. These workers also noted that newly hatched larvae can be held at 8 to 10° for a week and partially fed ones for two to three weeks. It has been found in work in this laboratory on deficient diets that small larvae can exist for a month at 25° and then grow normally when given proper food.

The prepupae are undoubtedly the best adapted for prolonged arresting of development. At 10° they have been kept for several weeks without serious loss. Cousin (1929e) has even reported that storage at 8° to 10° for five months did not prevent successful pupation after the temperature was raised, and Evans (1935a) found results similar to Cousin's under conditions of high humidity. The pupae are more sensitive to colder temperatures and one week at 5° has been found to cause poor emergence and short lived adults, particularly if the pupae are over two days old when they are chilled. Placing pupae at 10° one or two days before the end of that stage does not prevent emergence but only delays it. Haub & Miller (1932) found that over three weeks at 8° led to malformed flies.

It is obvious from the experience in this and other laboratories that the normal life cycle of *Lucilia sericata* can be interrupted at several points, chiefly by reducing the temperature, but also by depriving the larvae of food. Under laboratory conditions no evidence of hibernation or of diapause has been noted, though fertile egg production is lower in the winter months unless precautions are occasionally taken to illuminate the flies artificially. This is probably explained by the observation of Cousin (1929b) that copulation occurs almost exclusively in bright light.

OTHER SPECIES REARED.—Not only *Lucilia sericata*, but *Phormia regina*, *Sarcophaga bullata* and *Cochliomyia macellaria* have been reared for many generations in the laboratory by the general procedure given above. The latter fly is particularly interesting in this respect for various workers have gone to great exer-

tions to raise it upon living animals, and the available evidence indicates that the closely related *Cochliomyia americana* begins its development in nature only in the tissues of live animals (Laake, *et al.* 1936). It seems probable that any flesh fly can be reared in the laboratory upon fish heads if its particular physical requirements are known and observed.

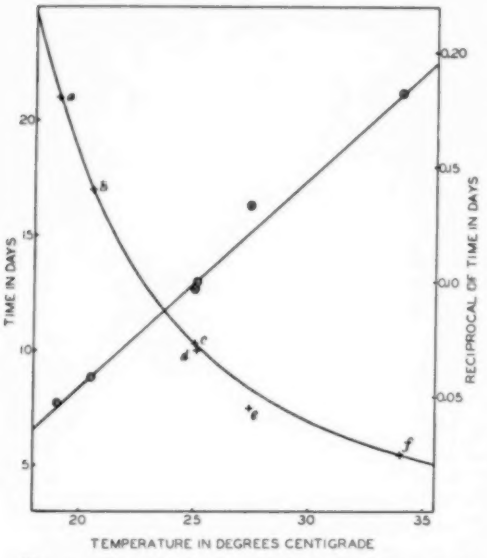

FIG. 1.—Preoviposition periods for *Lucilia sericata* at several temperatures, on diet of fish head, sugar and water. Point *a*, 19° continuously; point *b*, 28° for 4 hours, 19° for 20 hours daily, weighted average temperature, 20.5°; point *c*, 25° continuously; point *d*, 25° continuously except for 20 minutes daily under General Electric Sunlamp, type AA, at distance of 2 feet, temperature in center of cage 34.5°, average weighted temperature 25.1°; point *e*, under Sunlamp as in d for 6 hours, at 25° for 18 hours daily, weighted average temperature 27.4°; point *f*, 34° continuously.

TIME REQUIRED.—Using the methods described above, it is possible for one person working four hours daily to rear 2,000 to 3,000 adult flies or any other stage of the life cycle desired. This low labor cost combined with cheap food makes flesh flies among the least expensive insects for large scale rearing.

PRODUCTION OF FERTILE EGGS.—No matter what stage of a living insect is being studied, the steady output of fertile eggs is of fundamental importance. Many conditions have to do with this, e.g., food of the flies as larvae and as adults, opportunity for mating, temperature and attractive material for egg deposition. Numerous workers have published their results on one or more of these and other points, but quantitative data are still meager. One important factor is the time that must elapse after emergence of the female fly before eggs can be laid. This is dependent upon both temperature and food.

TEMPERATURE.—Smit (1928) in South Africa observed a seasonal variation under natural conditions from five days during the summer (January) to 29 days in winter (August). Cousin (1929c) reared *Lucilia sericata* in the laboratory on horse meat and found that the shortest life cycle occurred at 33° and the preoviposition period was seven to eight days. Mackerras (1933) claimed that all ovary development occurs after a protein meal and that at 20° to 22° eggs were laid after five to six days on a diet containing liver and cane sugar. Such inconsistent data prompted an investigation of the effect of temperature upon the time required after emergence for the first egg laying.

Lucilia sericata adults, whose time of emergence was known within two hours, were placed at the temperature indicated in the legend of fig. 1. Water, cube sugar and a fish head were continuously before them. The experiments were carried out during April and May; so there was direct but oblique sunlight through the north window upon the cages during the late afternoon. The time of first deposition of eggs was determined by frequent examination. The largest error involved in any one run was not over five hours at the most and in many cases was only a few minutes.

Averages of a number of runs at each temperature are shown in the figure. These apply only to the first eggs laid in each run and give no indication as to the behavior of the several hundred other females present in each cage. However, the first laying was almost invariably followed at once by numerous others so that within 24 hours tremendous numbers of eggs were secured. The temperatures are known to within half a degree except in the case of six hours exposure to the sun lamp (point *e*). In this case there was a decided temperature gradient and that of the center of the cage is used in fig. 1. It is entirely possible that the inconsistency of the data for this experiment is due to uncertainty in the temperature.

Points *b*, *d* and *e* represent the temperature as the weighed average of the two actual temperatures used each day. In the case of point *b* (4 hours at 28°, 20 hours at 19°) there is no indication that either acceleration or retardation was caused by the alternating temperature, and point *e*, on account of uncertainty as to the actual temperature, gives no information on this point. Ten minutes exposure per day to the sun lamp (point *d*) had no perceptible effect upon the preoviposition period.

In fig. 1 a plot is also given of the temperature versus the reciprocal of the time required. Pearis (1927) and Wardle (1930) have found this relation to give a straight line over a limited temperature range for the larval and pupal periods of several flesh flies. The significance of this is that temperature multiplied by required time is a constant. It is obvious from the figure that this relation holds well for the preoviposition period. By extrapolation the developmental zero may be calculated as approximately 14°. In accordance with other biological processes this calculated zero is undoubtedly too high (Hoskins & Craig, 1935, p. 537) but it is so far above the corresponding temperatures found by Wardle (1930) for the preimaginal stages (4.2° to 5.6°) as to leave no doubt that egg formation within the body of the female fly is more sensitive to low temperature than are the other stages of the life cycle.

Data on the complete life cycle of *Lucilia sericata* at 25° may be summarized from egg to egg as follows: eggs hatch in 12 to 18 hours, larval feeding period 3 to 3½ days, prepupal non-feeding period 3 days, pupal period 8 to 9 days, or a total of 14½ to 16 days for the preimaginal stages. This agrees well with Wardle's (1930) data of 13 to 21 days for the same insect fed upon ox liver at 26°. With an average minimum preoviposition period of approximately 10½ days this gives an entire egg to egg cycle of 25 to 26½ days. An allowance of one more day in order to include the preoviposition period of a large percentage of all females gives a practical life cycle of 26 to 27½ days at 25°.

A few data on the preimaginal period at other temperatures show 18 to 20 days at 20°, and 11 to 13 days at 30°. These periods together with the corresponding lengths of time for preoviposition, i.e., 19 days at 20° and 7 days at 30° (interpolation from fig. 1 plus one day), give the practical total life cycles as 38 and 19½ days, respectively.

The corresponding complete data for *Cochliomyia macellaria* at 25° are as follows: eggs hatch in 12 to 18 hours, larval feeding period 2 to 3 days, prepupal nonfeeding period 2 to 3 days, pupal period 4 to 5 days or a total preimaginal time 8½ to 12 days. The preoviposition period is 5 to 8 days (average not determined); so the practical life cycle is approximately 10 plus 6 or 16 days at 25°. Accordingly the life cycle of this insect is about 40 per cent shorter than that of *Lucilia sericata*.

DIET.—It seems to be generally agreed that water and carbohydrate are sufficient to maintain life of either sex of adult flesh flies but that protein is needed by the female before growth of the ovaries can start. Cousin (1929a) considered nucleo-protein to be essential but Haub & Miller (1932) fed their flies only sugar and lean beef, which contain but little nucleo-protein. Mackerras (1933) found fresh liver alone sufficient. This is very interesting in the light of Fraenkel's (1936) discovery that glycogen, which is synthesized and stored in the liver, can be utilized by the flesh fly, *Calliphora erythrocephala*, and presumably by other species.

A series of experiments was carried out to test the sufficiency of several diets for egg laying and longevity. As related before, with fish, sugar and water, fertile eggs were always produced in about 10 days, and the flies lived approximately two months.

Omission of the fish allowed no growth of the ovaries (as proved by dissection) and the length of life was but slightly longer. When fish was added after a sugar diet of two, three or six weeks, fertile eggs were produced 10 days thereafter. This indicates that age of itself has no effect upon the food requirements or the time needed for growth of the ovaries and is somewhat in contrast to Mackerras' (1933) finding that eggs were laid within two to three days after fresh liver was added to a previous carbohydrate diet. When fish and water were given but no sugar all of the flies died within three to four days at 25° and within a week at room temperature of about 19°. These

are nearly the same as the starvation periods on water only (Evans 1935b).

Several other protein foods were used with sugar and water but, while the flies lived from six to eight weeks, no development of the ovaries occurred. The foods were: casein plus butter and yeast (i.e., the successful larval food found by Michelbacher *et al.* 1932); casein rendered soluble by a minimum quantity of either sodium or ammonium hydroxide; blood albumin; and Lemco beef extract. It is clear that some proteins are not adequate for egg formation, but the failure of the diets may be due to lack of accessory factors rather than to a specific protein deficiency.

OTHER FACTORS.—When fish, sugar and water were kept before flies in complete darkness, no eggs were laid and all flies died within 17 days. Observation from time to time showed that food was partaken of to some extent, but difficulty in finding both the food and the water probably led to a condition of semistarvation that accounts for the short life.

During the course of certain experiments with sterile diets, eggs from two cages of flies were being sterilized by dipping in 3 per cent Lysol solution for two minutes (Michelbacher *et al.* 1932). This continued with excellent results until the flies were 45 days old when hatching suddenly became very poor. Observation showed a few males still to be present, although, in agreement with the observation of Cowan (1932) on *Phormia regina*, the sex ratio has been found to alter uniformly from approximate unity for the first few days to zero (M/F) at the end of about 50 days, and fertile eggs continue to be fertile for at least 12 days after males disappear either by death or forceful withdrawal. It was found that unsterilized eggs from these same two groups hatched normally. These observations, together with others on eggs from old flies showed that they are more sensitive to the ordinary sterilizing agents than are the eggs of young flies. Hexylresorcinol at 0.5 per cent for five minutes was found to kill all the microorganisms without destroying the viability of the eggs.

SUMMARY.—Eight years of experience with the rearing of *Lucilia sericata* in large numbers in the laboratory has led to the development of convenient and labor saving apparatus and procedures which are fully described. Fish heads for the larvae and water, sugar and fish heads for the adults are cheap and nutritionally satisfactory as foods. Data are given on the effect of temperature upon the duration of the various developmental stages and of the whole life cycle. The various stages, particularly the prepupal, may be effectively retarded by chilling. The quantitative relation of temperature to the length of the preoviposition time has been studied. The developmental zero of egg formation as determined by extrapolation of the temperature-rate line is about 14°. Carbohydrate is essential for continued life of the adult fly and protein for growth of the ovaries. Casein, sodium or ammonium caseinate, blood albumin or Lemco's beef extract did not allow ovary development. The eggs of old flies are more sensitive to sterilizing agents such as Lysol than are the eggs of young flies.—9-10-37.

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The Hydrogen Ion Concentration and Buffer Value of the Blood of Larvae of *Pieris rapae* (L.) and *Heliothis obsoleta* (F.)*

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In the study of the mode of action of poisons on the various insect organ systems, it is desirable to know not only the normal pH of the particular system studied, but also any buffer action which may be present. A buffer will not only resist change in the existing pH upon the addition of acidic or basic poisons but will also neutralize acids or bases formed as a consequence of any material taken into the system. Hoskins & Harrison (1934) have made such a study of the digestive tract of the honey bee, in which they show definite buffer systems to be present; at a pH of 4.15 an unknown buffer system gives a maximum buffer value of 0.094, expressed in equivalents per liter of solution, and at pH 6.8 the buffer value is 0.024, corresponding to a phosphate concentration of 0.046 molar. An analysis of the blood gave a phosphorus content of about 0.06 molar, which showed that phosphate is available to serve as a buffer system.

The resistance of an organism to the effects of a poison is closely connected with the mechanism of the toxic action. Skrjabina (1936) shows that varying toxic effects of certain insecticides are theoretically accounted for by the fact that for different pH values there occur differences in solubility, degree of dissociation, hydrolysis and other properties of a solute. Hoskins (1932) has shown that as a solution of arsenious acid becomes more acid, that is, as the pH decreases, its toxicity to mosquito pupae is

* Contribution from the laboratory of insect physiology and toxicology, Division of Entomology and Parasitology, University of California.

greatly increased. Pearson and Richardson (1933), using the housefly as the experimental insect, found that an increase in acidity did not yield a corresponding increase in toxicity and attributed this fact to an efficient buffering system in the digestive tract.

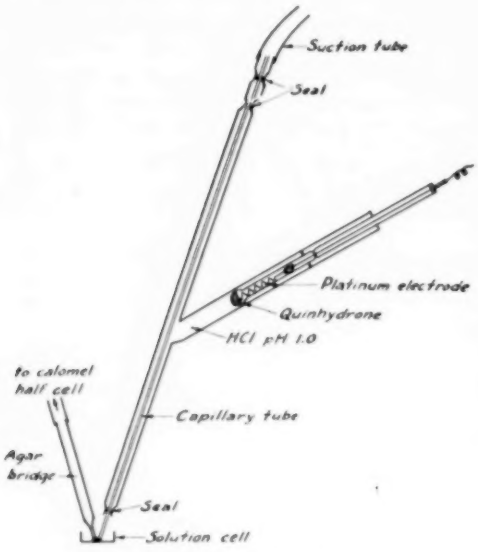


FIG. 1.—Capillary glass electrode.

An excellent review of the work that has been done on the pH of insect blood is given by Wigglesworth (1934), who states that the blood is moderately well buffered, which he thinks is due to a phosphate system in conjunction with the plasma proteins, since the bicarbonate content is quite low. Bishop (1923) believed that since blood was the immediate destination of histolytic debris during the disintegration of the larval tissue and since histolysis results in acid production, the buffer action of the blood must be significant. Bodine (1926) concluded that there must be some buffer action in grasshopper blood, since there were no marked changes in pH upon dilutions up to fourfold.

It is evident that a knowledge of the buffering effect of the blood may have an important bearing on the understanding of the physiological action of insecticides, the study of which is one of the problems of this department, and although it is generally stated that there must be some buffer action in the blood, it has never before actually been measured.

METHOD OF OBTAINING DATA.—Because of the pigmentation of insect blood and its chemical constitution, the only satisfactory method of determining pH values during the process of titration was found to be the use of a glass electrode. The capillary electrode used in determining the pH of the titrated blood has proved quite satisfactory and is capable of handling volumes of 50λ (0.050 cc.) or less. The electrode itself (fig. 1) consists primarily of a straight Pyrex glass tube pinched in at either end through which the capillary passes and is sealed in with Kronig's cement. The capillary is drawn to a bore of about 0.5 mm. from 015 Corning glass, and is about 22 cm. long between seals. Suction is applied through a rubber tube on the upper end to fill the capillary, and the level is maintained by a clamp. The capillary is easily rinsed by drawing water in and out of the tube. About half way up the Pyrex tube another tube of the same size joins it, and this contains the quinhydrone-platinum electrode in HCl solution of pH 1.00. A somewhat similar electrode has been recently described by Pickford (1937).

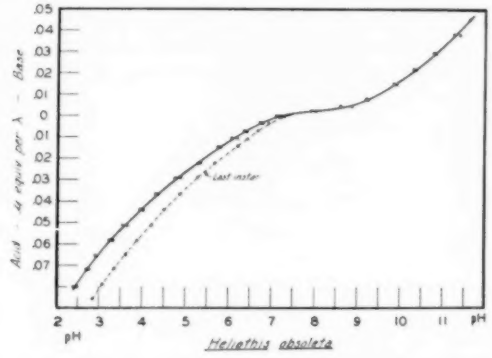
The capillary most used in this work had a volume of 60λ, although others of smaller volume were constructed and used satisfactorily. It was found necessary to age the capillaries by soaking in distilled water for a few days; they were then good for an indefinite number of runs. The electrodes checked closely with the theoretical value, although slight variations necessitated checking against standard buffer solutions before and after each run. A standard calomel half-cell calibrated against a known buffer completed the unit (Clark 1928).

The apparatus for measuring the potential difference across the glass membrane consisted of a single thermionic tube electrometer circuit designed by Du Bridge & Brown (1933), a type K Leeds and Northrup potentiometer, and a type HS Leeds and Northrup reflecting galvanometer. The micro-buret described by Kirk (1933) used in titrating had a capacity of 110.5λ. The pipette used to draw up the blood from an incised proleg was of the type described by Kirk & Craig (1932).

It was found desirable to dilute the blood two- or threefold to provide enough fluid to make contact with the electrodes, and this did not appreciably change the

pH readings. The acid or base added during titration amounted to less than a one-fold dilution.

The blood sample of each individual was titrated immediately with either 0.1 N HCl or 0.1 N KOH. The titration curve drawn (fig. 2) is an average of several determinations. To obtain the buffer value curve, the slope of the tangent to the curve at each desired pH value was taken. These values were plotted in units of equivalents of acid or base against pH, and represent the differential ratio between the increment of a strong acid or base added to a buffer solution and the resultant increment in pH. For a complete discussion of buffer values and their significance see Hoskins and Harrison (1934) or Van Slyke (1922).



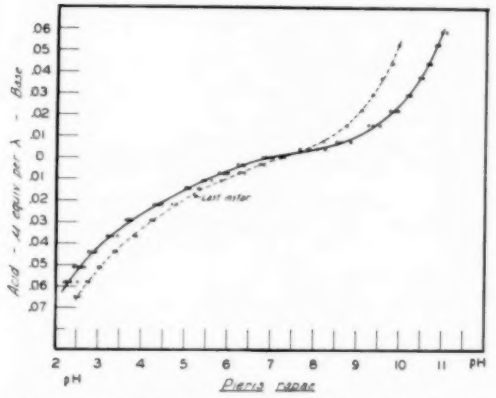


FIG. 2.—Titration curves. Broken line, last instar larvae; full line, next to the last instar larvae.

Because of their availability to this laboratory, tests were run on larvae of *Pieris rapae* (L.), the common cabbage butterfly, and of *Heliothis obsoleta* (F.), the corn ear worm. The larvae used were separated into two groups for each species, namely, last instar larvae and next to the last instar larvae.

CONCLUSIONS.—As was expected from previous work, individual variation was shown, but the differences were small. Although no attempt was made to correlate pH with age, it was found that the

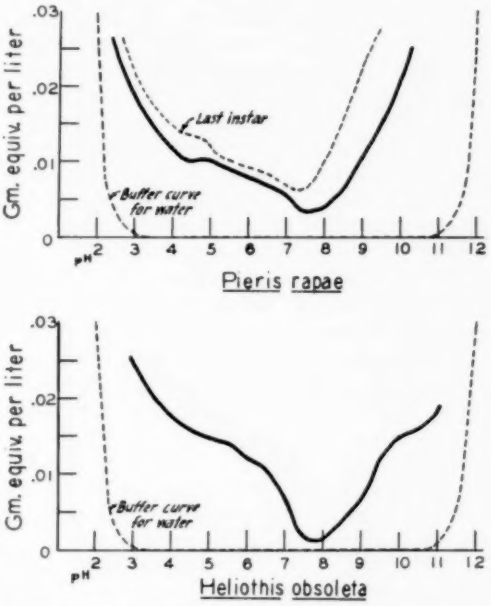


FIG. 3.—Buffer curves. Broken line, last instar larvae; full line, next to the last instar larvae.

caterpillars in the last instar gave a definitely more alkaline reaction than those of the next earlier instar. Of sixteen samples the pH values were as follows: *Pieris*, last instar, 7.02 to 7.56, average 7.17; next to the last instar, 6.76 to 7.0, average 6.9; *Heliothis*, last instar, 7.16 to 7.3, average 7.23; next to the last instar, 6.66 to 6.88, average 6.79.

No single definite buffer system is evident on the buffer value curves shown in fig. 3. There is a general buffer effect shown in the region of pH 4 to 7.5, however, which is probably due to the composite effect of the salt buffers of this range and the plasma proteins. The buffer value of water as seen on the chart is close to zero until the hydrogen or hydroxyl ion concentration exceeds about 10^{-3}, when the buffer effect of the residual ions enters. The same effect enters the buffer curve of the blood at these extreme values, and the buffer value is relative at these points rather than absolute. The

significant biological range falls within much narrower limits.

The buffer value at a pH near 4.5 to 5.0 with *Pieris* is about 0.01, which is equivalent to 0.0175 molar acid having a pKa value of 4.7 acting as a buffer solution. The buffer curve for *Heliothis* is slightly higher until alkalinity is reached, when a somewhat lower buffer effect is noted. There also seems to be a slightly stronger buffered region on the latter curve between a pH of 9.5 and 10, although it may not be significant. In both cases the buffer curve of the last instars is distinctly higher than that of the preceding instar.

Both species tested have a rather low buffer action toward any weak acid that may enter the blood stream. The buffering action is greatest near or slightly below the normal pH of the blood.

Further work along this line should be pursued in conjunction with water balance and salt and protein concentration studies, as these are all factors that affect the pH and buffer value of the blood.

SUMMARY.—Since a knowledge of the pH and buffer value of insect blood is of value in interpreting the physiological action of insecticides, samples of larval blood of *Pieris rapae* (L.) and *Heliothis obsoleta* (F.) were titrated, and both titration and buffer value curves drawn.

Capillary glass electrodes capable of handling a volume of 50λ or less were constructed, and the potential differences were measured with a modified Du Bridge and Hart single thermionic tube electrometer circuit.

There is a low but effective buffer system present, probably composed of several salts and proteins, about the pH range of 4 to 7.5. Both the normal pH and the buffer value of the larval blood in the last instar were greater than those of the preceding instar.—10-25-37.

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THE 1937 LEGISLATURES of Pennsylvania, Oklahoma and Kansas brought about changes in the nursery stock shipping laws of these states. In Pennsylvania, herbaceous biennials are included in the new definition of nursery stock. The definition excludes bulbs as heretofore. In Oklahoma a bond is no longer required for dealers, and the permit fees for dealers and nurserymen have been changed to $5 or $10, depending upon the volume and type of business. The new definition of nursery stock adds collected wild plants, but exempts "vegetable plants, roots and bulbs used for the production of food." The present Kansas law requires a license and fee of $5 for dealers and landscape gardeners to do business in the state and provides for making reciprocal agreements between the Kansas Entomological Commission and officers of other states as to fees, special inspections, bonds, etc.

NO FEE whatsoever is charged to out-of-state nurserymen doing business in Missouri under the regulations revised, effective September 6, 1937.

AREAS regulated under Federal quarantines relating to the pink bollworm of cotton and the Dutch elm disease were recently extended to include small additions under recent revisions of the regulations.

Effectiveness of Fluorine Compounds as Food Poisons for the Firebrat[1]

E. J. Seiferle, J. A. Adams, C. M. Nagel and W. C. Ho, *Iowa State College, Ames*[2]

The history of the adoption of fluorine compounds as insecticides has been briefly reviewed by Marcovitch (1928). The use of fluorides for the control of household Thysanura in America seems to have begun between 1915 and 1917. The effectiveness of sodium fluoride as a poison dust for cockroaches led Marlatt (1915) to suggest its use for the control of the silverfish, *Lepisma saccharina* L. and the firebrat, *Thermobia domestica* (Pack.).

Published Records.—Among the earliest published records of the actual use of a fluoride against silverfish are two brief reports from Canada. Gibson (1916) had used sodium fluoride as a dust for carpenter ants. Finding the compound very effective, he tested it on other household insects, including the silverfish. Reference to his results is contained on page 18 of the *Report of the Dominion Entomologist* for 1917 and 1918 (1920). Similar results were announced in the *Report of the Department of Entomology*, Ontario Agricultural College (1918).

Spencer (1924), working with the firebrat, performed tests with various poisons mixed with various foods and recommended a bait for these insects consisting of sodium fluoride and wheat flour. Wakeland & Waters (1931) did extensive experiments upon the food preferences of the firebrat and worked out a food mixture consisting of oatmeal, white sugar and common salt; to this was added arsenic trioxide. Water was used to combine the ingredients. Snipes, Hutchins & Adams (1936) found that at 34.5° C. sodium fluoride was more rapidly effective on firebrats than was arsenic trioxide, and they recommended a bait similar to that of Wakeland & Waters but prepared without the use of moisture and containing sodium fluoride as 7 per cent of the weight. In the meantime Marcovitch (1933) recommended a bait for silverfish consisting of five to eight parts of wheat flour to one part of sodium fluosilicate.

The possibility that sodium fluoride might not be the most effective of the available fluorine compounds for the firebrat stimulated the undertaking of the experiments described below. The purpose of this investigation was to determine the relative effectiveness of various fluorine compounds in comparison with sodium fluoride as food poisons for the firebrat, *Thermobia domestica*.

Methods and Experiments.—These experiments were performed in the same laboratory and with about the same methods as those of Snipes, Hutchins & Adams (1936). The firebrats were drawn from the same laboratory culture begun in 1931 and maintained under controlled conditions (Adams 1933). The culture of these insects was infected with the characteristic gregarines of the firebrat, *Lepismatophila thermobiae* Adams & Travis, and *Colepismatophila watsonae* Adams & Travis, which seem to cause little harm to the host (Adams & Travis 1935). The individuals used exceeded 7 mm. in length but were otherwise unselected. Open shell vials, 50 mm. in height and 25 mm. in diameter, were used for the experiments, one for each insect. Except in the starvation controls, approximately .03 gram of food or bait was placed in the bottom of each vial. This amount is much in excess of that likely to be consumed by the insect.

A strip of paper three inches long and three-fourths of an inch in width, pleated transversely, was placed on edge in the bottom of each vial. This paper served as a perch suited to the habits of the firebrat, thus enabling it to remain out of direct contact with the poison mixture except when feeding. To further preclude contact effects, the materials were placed in the vial in the following order: mixture, paper, insect. To insure prompt feeding, the firebrats were starved for 24 hours before being placed in the vials.

The experimental insects were kept in a constant temperature cabinet at about 38.5° C. and 70 to 75 per cent relative

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[2] The authors are indebted to Dr. C. H. Richardson under whose direction this investigation was conducted, to Dr. A. E. Brandt who gave counsel on the statistical treatment of the data and to Dr. G. C. Decker for his valuable suggestions on methods.

humidity. This temperature was chosen because it is approximately that preferred by firebrats (Adams 1937). The air in the cabinet was kept in slow circulation. Survival counts were made at 12-hour intervals and each series of trials was continued for at least two weeks. Failure to respond to pinching of the antennae or tarsi served as the criterion of death.

The compounds studied were chemically pure samples of sodium fluoride and sodium fluosilicate, a pure commercial sample of barium fluosilicate and the synthetic cryolite, "Alorco," which contained 84.3 per cent Na_3AlF_6. The interesting physical properties of "Alorco" have been described by Marcovitch and Stanley (1936).

The food mixture consisted of finely ground rolled oats, powdered confectioners' sugar and powdered, chemically pure sodium chloride in the proportions 200: 10:5. The poison baits were made by mixing this food intimately with quantities of the above-mentioned compounds such that the poisons were 4, 8 and 12 per cent by weight of the bait.

Sixty insects, six replications of ten each, were used in each experiment. The replications were started at three-day intervals. In addition, two sets of controls were used; in the first set, both food and poison were lacking; in the second, the unpoisoned, standard food mixture alone was administered. Except in the starvation controls, the bait or unpoisoned food was available to the insect for the duration of these experiments.

Because of observations and data obtained in the early stages of the investigation, a new series of experiments was added in which the 12 per cent baits were used. After the insects had been allowed to feed for 24 hours, they were transferred for the duration of the experiment to clean vials, which contained neither food nor poison. The 12 per cent starvation tests were made only on sodium fluosilicate, barium fluosilicate and sodium fluoaluminate.

RECORDING RESULTS.—The control insects which were provided with food showed a mortality of one insect during the course of the experiment, while the starvation controls or those insects which had neither food nor poison showed a mortality of one insect in seven days and 10 per cent in 14 days. Therefore, control mortality may be disregarded in the regular toxicity tests.

The data accumulated in these tests are presented in a graphic form suggested by Broadbent & Bliss (1936) for plotting time-mortality data. The ordinates, per cent survival, are expressed in probits or probability units (Bliss 1935) and the abscissae are either time of survival in hours or logarithms of time. The choice of time or log-time units was made by inspection of the approach to linearity of the data thus plotted. Straight lines are fitted to the data by the method of least squares and are shown by the chi-square test to be in excellent agreement ($P > 0.99$).

In fig. 1 the data and fitted curves are plotted for the three concentrations of poison for each of the four compounds.

Analysis of variance was made by a method similar to that of Pearson (1934), the F tables of Snedecor (1934) being used to test significance. These tests serve to indicate (1) whether one regression formula can be used for all the data at all concentrations of each compound, (2) whether there is a significant variation among the slopes of the lines and (3) whether the regression of the means of the variables is linear. The results of this analysis are shown in table 1.

Table 1.—Results of analysis of variance in comparing data of 4, 8 and 12 per cent concentrations of poisons in baits.

Compound	Variance Tests on: Deviation from use of single regression formula	Deviation of slopes among curves	Deviation of means from linearity
Sodium fluoride	h.s.	n.s.	h.s.
Sodium fluosilicate	h.s.	n.s.	h.s.
Barium fluosilicate	s.	s.	n.s.
Sodium fluoaluminate	h.s.	h.s.	h.s.

n.s. = no significant deviation ($P > 0.05$); s = significant deviation ($P < 0.05$); h.s. = highly significant deviation ($P < 0.01$).

RESULTS.—Table 1 and fig. 1(a) show that, for sodium fluoride, the deviations are most probably due to the displacement of the 4 per cent curve. Consequently there appears to be a significant difference between the effect of the 4 per cent concentration and the effects of the other two, the curves for which are ob-

viously only slightly displaced one from the other.

The analytical data and fig. 1(b) indicate that the effects of the various concentrations of sodium fluosilicate are significantly different. All three concentrations appear to contribute almost equally to the deviation from unilinearity, this deviation being due perhaps largely to displacement of the curves since the slopes are very similar.

A different interpretation may be placed on the data for barium fluosilicate. Here the deviation from unilinearity appears to be due to variations in slope of the curves rather than to their displacement. This statement is borne out by the test which showed that the means of the variables are practically linear and a further test (Pearson 1934) that indicated no significant deviation in the slope of the line of the means from the general slope of the fitted data curves.

The data on sodium fluoaluminate are virtually self-explanatory, the deviations being due both to the difference in slope of the 12 per cent curve and the displacement of all the curves from each other.

It was noted early in the experiments that sodium fluoride produced rather high mortality during the first 24 hours, there being 27 to 53 per cent death in this period, according to concentration of poison. The other compounds, on the contrary, killed relatively few insects in 24 hours, barium fluosilicate killing 0 to 5 per cent, sodium fluoaluminate 2 to 3 per cent and sodium fluosilicate 8 to 17 per cent. Among possible explanations for this variation the following are considered: (1) these salts exhibit slower lethal action, (2) the insects are repelled at first, eating the poisoned baits only after longer starvation and (3) insufficient poison is consumed during the first 24-hour feeding period to constitute a fatal dose.

To eliminate one or more of these explanations for the observed variation a series of experiments, described above under "Methods and Experiments" as the 12 per cent starvation series, was begun.

DISCUSSION.—The data derived from this series of experiments showed for sodium fluosilicate and barium fluosilicate a rather close similarity to that of the regular 12 per cent experiment down to a survival of about 20 per cent, after which there appeared a tendency for the curve of the starvation technique to become asymptotic with the axis of zero survival. Sodium fluosilicate showed 14 and barium fluosilicate 15 per cent survival when all had died in the regular tests. This marked tendency is perhaps largely due either to

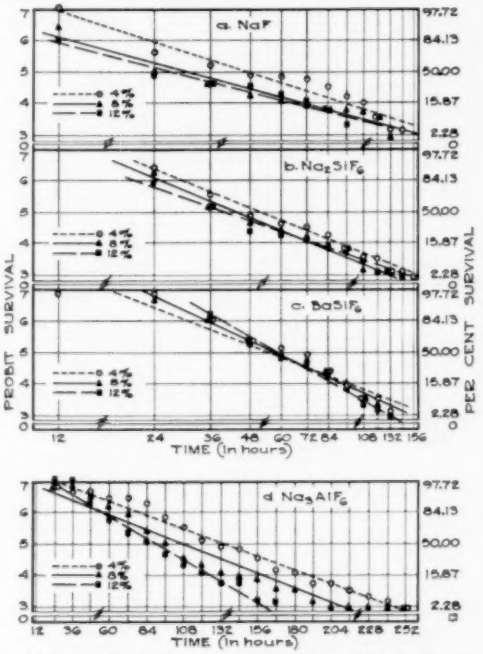

FIG. 1.—Trend of survival of the firebrat with time, as affected by various concentrations of certain fluorine compounds in baits available to the insects till death. Points represent mean per cent survival of 60 insects in 6 groups of 10 each.

high resistance of the individual insects concerned or to the fact that little or no bait was consumed during the first 24 hours. The data on sodium fluoaluminate showed immediate deviation of the starvation technique from the regular. The asymptotic tendency was also made strongly manifest by the fact that 30 per cent of the insects survived at the end of 14 days (336 hours).

Some starvation effect enters into the data of the 12 per cent starvation series for there was 10 per cent death between the seventh and fourteenth days among the starvation controls. This, however, was considered negligible.

It appeared desirable to compare statistically the regular 12 per cent data with those of the 12 per cent starvation series for these three compounds. In order to do this the data for the period after the ap-

pearance of the asymptotic tendency was discarded and curves were fitted as before to the data up to about the time for 15 per cent survival according to the regular experiment. These data are shown in fig. 2. Tests of significance were made and the results appear in table 2.

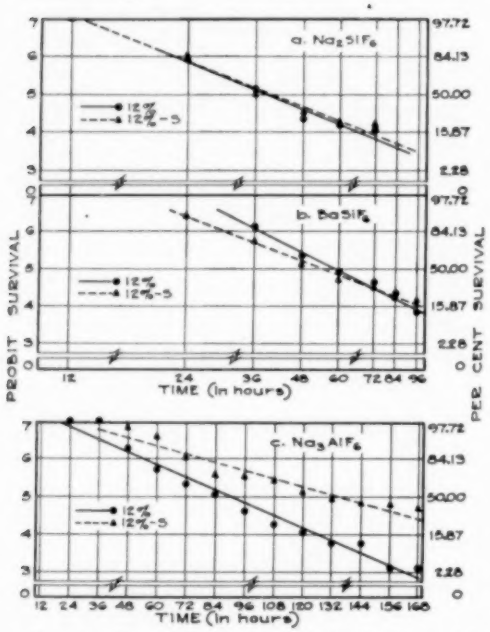

FIG. 2.—Trend of survival of the firebrat with time; comparison of effects of continued access of the insects to the poison bait until death (12%) and of removing the bait after the first 24 hours, followed by starvation (12%-S). Points have same significance as in fig. 1.

The curves fitted to the sodium fluosilicate data are seen to be almost superimposed, there being only a slight deviation in slope which seems to be unimportant since one regression formula can be used for all the data. Therefore, it appears that, in comparing sodium fluosilicate and sodium fluoride poisoning of the firebrat, the delayed mortality of the former may be the result of slower action.

The barium fluosilicate data are not so completely coincidental, as indicated in table 2. It must be noted however that the deviation between the curves, due partially to difference in slope and probably partly to displacement, is in a direction which indicates that the 12 per cent starvation experiment was *more* effective in killing than was the regular test. Such an occurrence is seldom to be expected in biological experiments of this type and hence the probability of its repetition is very slight. It is possible to state then with a fair degree of likelihood that the delayed mortality in the case of barium fluosilicate is the result of the slower action of this poison.

The work on sodium fluoaluminate indicates that the delayed mortality for this compound is probably due either to repellence or to the greater resistance of the firebrat to the amount of poison consumed in the first 24 hours.

As an arbitrary means of comparing the three concentrations of the several poisons, the times in hours to kill 50 per cent of the insects (median lethal time) were read directly from the curves of fig. 1 and were tabulated in table 3.

Table 2.—Results of analysis of variance in comparing data of 12 per cent and 12 per cent starvation techniques.

Compound	Variance Tests on: Deviation from use of single regression formula	Deviation of slopes among curves	Deviation of means from linearity
Sodium fluosilicate	n.s.	s.	—
Barium fluosilicate	h.s.	h.s.	—
Sodium fluoaluminate	h.s.	h.s.	—

n.s. = no significant deviation ($P > 0.05$); s = significant deviation ($P < 0.05$); h.s. = highly significant deviation ($P < 0.01$).

Table 3.—Median lethal time in hours.

Compound	4%	8%	12%
Sodium fluoride	47	30	28
Sodium fluosilicate	51	44	39
Barium fluosilicate	56	58	58
Sodium fluoaluminate	134	108	90

From these data it is evident that the 8 per cent concentration of sodium fluoride shows a much decreased time of kill when compared with the 4 per cent concentration. Little advantage, however, is to be gained by increasing the poison content to 12 per cent. It is of interest to compare these results with those of Snipes, Hutchins & Adams (1936) from this laboratory. They found also that the curves of the 8 and 12 per cent data nearly coincide, while the 4 per cent curve is considerably displaced. However, their median lethal times were from 15 to 20 hours greater. This is undoubtedly due,

for the most part, to the fact that these authors confined their insects at 34.5° C. whereas the insects used in the experiments reported here were kept at about 38.5° C. Since the firebrat is thermophilic it is to be expected that its life processes would be quickened and consequently the survival time shortened at higher temperatures.

A steady decrease of median lethal time with increased concentration of sodium fluosilicate is evidence that the stronger the dosage the greater its effectiveness as regards speed of action. On the other hand, the fact that the median lethal times for the three barium fluosilicate concentrations are almost identical leads to the conclusion that a 4 per cent bait is equally as satisfactory as is either of the higher concentrations. Neither sodium nor barium fluosilicate manifests a toxic action to any appreciable extent within the first 24 hours after ingestion; i.e., they are, relative to sodium fluoride, slower acting poisons.

The widely separated median lethal times for sodium fluoaluminate indicate that the effectiveness of this compound increases with increased concentration. The delayed mortality after the bait is made available to the insects is probably due either to appreciable repellence or to greater resistance of the insects to the action of this poison.

Despite the fact that sodium fluoride shows a much greater initial kill than do the other three compounds, it is important to note that 100 per cent mortality is attained by sodium fluoride and both fluosilicates at nearly the same time. Thus the rate of kill for the latter compounds after the first 24 hours is greater than for sodium fluoride. Sodium fluoaluminate also gives complete kill but in a greater time.

PRACTICAL RECOMMENDATIONS.—Due to the fact that sodium fluoride is at present cheaper than the other fluorine compounds studied, no change is thought necessary in the bait recommended by Snipes, Hutchins & Adams (1936), a 7 per cent by weight mixture.

It is worthy of note, nevertheless, that any of the other compounds used in 4 or 8 per cent concentrations should be equally as effective in controlling the firebrat as is sodium fluoride.

It should also be noted that these experiments were performed only with the firebrat, the thermophilic species. The practical recommendations likewise are intended to apply only to this species. The temperature and moisture requirements, and probably the food habits, of the silverfish are quite different.

SUMMARY.—The effects of sodium fluoride, sodium fluosilicate, barium fluosilicate and sodium fluoaluminate on the firebrat were studied. Each compound was mixed with a preferred food of the firebrat in 4, 8 and 12 per cent concentrations, the baits being continually available to the insects. Median lethal times are in the following order: sodium fluoride <sodium fluosilicate <barium fluosilicate <sodium fluoaluminate. All concentrations of these compounds produce 100 per cent mortality; sodium fluoride, sodium fluosilicate and barium fluosilicate in about the same time, and sodium fluoaluminate in a somewhat longer time.

Sodium fluoride killed 27 to 53 per cent of the insects in 24 hours, but the other compounds killed only a few insects in this period. Experiments made on the 12 per cent concentrations in which the bait was taken away from the insects after 24 hours indicate that the delayed mortalities with the two fluosilicates were due to their slower lethal action, while that of sodium fluoaluminate is probably due either to repellence or to high lethal dosage.—11-8-37.

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Nicotine Vaporizing Equipment for Field and Orchard Use

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The efficacy of nicotine fumes or vapor in the control of aphids in greenhouses has long been known to artisans concerned with the growing of plants under enclosed conditions. The application of nicotine vapor to the control of insect pests of orchard and field crops was reported by Smith, Meyer & Persing (1934). The term "Nicofumer" was applied to the vaporizing apparatus described. In response to the suggestion of a manufacturer that this term would be confusing with their well-known trade name, "Nicofume," the term originally proposed was abandoned in favor of the designation "nicotine vaporizer" as proposed by the same authors (1935). The results obtained by Smith & Persing (1935) in the control of the codling moth and the pea aphid,[1] data recently reported by Alsterlund and Compton (1937) on the control of the pea aphid, and results obtained in commercial use the past two years in the control of aphids on various truck crops, indicate that the nicotine vapor treatment may be regarded a permanent addition to existing methods of insect control. Reports indicate that between 150 and 200 vaporizers were in use the past year.

The success of the vapor method in the control of insects to which the method is applicable depends upon the practicability and efficiency of equipment used in vaporizing the nicotine and applying the vapor to infested crops. In the treatment of greenhouse pests, the common practice for many years has been to burn by slow combustion a specially prepared powder or paper impregnated with nicotine, and to permit the fumes to diffuse through the enclosure during a period of hours. This method and the composition of the powder were described by Schultz (1922). Attempts to adapt the "burning" method to the control of insects under out-of-door conditions have proved unsuccessful, first, because too much of the nicotine is destroyed by combustion and, second, because it is impracticable to produce and maintain an insecticidally effective concentration in the rapid treatment necessary for field and orchard conditions.

FIRST COMMERCIAL VAPORIZER.—Illustrations and descriptions of the vaporizing equipment used in the earlier investigations are given in the papers indicated above. In fig. 1 is shown a vaporizer designed and built in the summer of 1935 to meet the requirements of practical field and orchard use. The principal assemblage consists of a heavily constructed

[1] In tests on the control of the pea aphid, made by Smith and Persing in February, March and April, 1935 (results unpublished), 19.9 gallons of *Black Leaf 50* were applied and 51 acres of peas were treated. Where the equipment operated at or near its maximum efficiency, the application of 0.4 gallon per acre gave "commercial control"; that is, the kill was sufficiently high so that natural enemies at once gained control. With the application of 0.68 gallon per acre, the use of a dragsheet 100 feet in length that gave a coverage of 1½ minutes, at an atmospheric temperature of 82° F., a kill approximating 100 per cent was obtained.

two wheel trailer on which is mounted a $2\frac{3}{4}$ horsepower gasoline engine, a small air compressor, two nicotine storage tanks provided with gauges, a tank of butane, a vaporizing unit, a "vapor box" and a blower through which the vapor is drawn and discharged through a spreader upon the plants. The vaporizing unit consists of two sections of brass pipe 3 inches in diameter and 4 feet in length, burners for butane extending longitudinally below the pipes, a thermostat for maintaining the pipes at a temperature of 500° to 550° F., an atomizing device in the forward end of each pipe and a coil of tubing for preheating the air used in atomizing the nicotine and carrying the vapor to the blower. The "vapor box" receives the nicotine vapor and also the hot exhaust gases from the engine. The weight of the outfit is 850 pounds. The fishtail spreaders shown in fig. 1 are for use in applying vapor to orchard trees. In fig. 2 the machine is shown in use in treating peas for aphis. A certain amount of developmental work and field testing with this type of machine have been done by the John Bean Manufacturing Company.

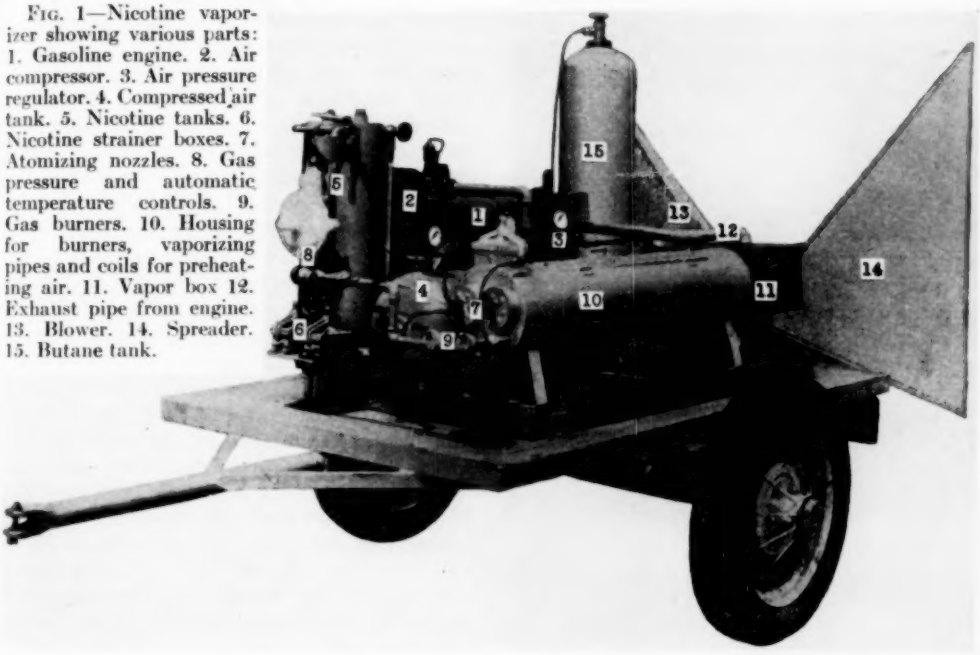

FIG. 1—Nicotine vaporizer showing various parts: 1. Gasoline engine. 2. Air compressor. 3. Air pressure regulator. 4. Compressed air tank. 5. Nicotine tanks. 6. Nicotine strainer boxes. 7. Atomizing nozzles. 8. Gas pressure and automatic temperature controls. 9. Gas burners. 10. Housing for burners, vaporizing pipes and coils for preheating air. 11. Vapor box 12. Exhaust pipe from engine. 13. Blower. 14. Spreader. 15. Butane tank.

In the past year or two, considerable use has been made of equipment which effects vaporization through the introduction of the nicotine into the exhaust mechanism of a gasoline engine. The original conceptions of this device were set forth by Savage (1932), but the vaporizing of nicotine was not then specifically contemplated. Developmental work and testing with this type of equipment has been done by the Tobacco By-Products and Chemical Corporation.

VAPORIZING NICOTINE.—Experience has shown that the attainment of the maximum effectiveness of a given quantity of nicotine depends upon four principal factors: (1) complete vaporization or gasification of the nicotine, (2) minimum condensation of the vapor within the conveying and spreading parts of the equipment, (3) maintenance of a high lethal concentration during an exposure period of one or two minutes, (4) treating at relatively high atmospheric temperature.

The equipment used in 1935 treated a strip 40 feet wide and moved at the rate of 100 feet in 1 to $1\frac{1}{2}$ minutes. The maximum capacity was 3 to 6 acres an hour, depending upon the rate of coverage. At atmospheric temperatures of 60° to 70° F., prevailing during the principal pea growing season in the coastal districts of California, it was necessary to vaporize

5 to 8 ounces of *Black Leaf 50* (an aqueous preparation containing 50 per cent nicotine alkaloid) per minute in order to obtain a satisfactory kill of the aphids. Despite the special provisions made in the machine with the design of obtaining complete vaporization, much loss was experienced due to unvaporized nicotine.

FIG. 2.—Three views of the nicotine vaporizer in operation in treating peas for aphis.

This difficulty was largely overcome in the machine shown in fig. 1, which was provided with automatic temperature control and with more efficient atomizing and heating devices.

VAPORIZATION BY HEATED COIL.—Recent experiments of the author have indicated that vaporization at any desired rate can be satisfactorily accomplished by the simple method of passing the liquid nicotine through tubing of small diameter arranged into a coil and heated directly by a gasoline burner. The coil method received consideration by Smith, Meyer and Persing in the earlier work when an attempt was made to provide heat to a coil with a bath of high boiling-point oil. In the recent experiments the nicotine was passed through tubing of one-sixteenth inch inside diameter, made into a coil and attached to a gasoline blowtorch. The discharge tip of the tubing extended 3 inches to one side of the flame. Tests made with aphids and the common housefly under controlled conditions in a fumitorium indicate that the toxicity of the nicotine was not adversely affected even when the coil was heated to a glowing white condition. An atomizer bulb was used to force the nicotine from a closed container through the coil. Owing to the expansion resulting from vaporization, the vapor was forcibly ejected to a considerable distance from the tip of the tubing.

The coil vaporizer has been used successfully in treating thrips and aphids infesting low growing shrubs, and in treating melons for aphids. The vapor, discharged under a canvas that was spread over the shrubs and vines, apparently gave 100 per cent kill of the aphids. The application of nicotine dust and nicotine spray had not given satisfactory results. It appears that the coil vaporizer may be utilized in field equipment, and that it will overcome the difficulty of incomplete vaporization of the liquid nicotine and provide certain advantages of simplicity and economy.

DIFFUSING VAPOR.—Field experiments and practice have shown that high lethal effects are obtained by suddenly exposing the insects to a high concentration of the vapor and maintaining a relatively high concentration for a short period of time. In order to maintain a high concentration and to reduce loss resulting from condensation, it is desirable to transport the vapor rapidly through the spreader and diffuse it through the infested plants in the shortest possible interval of time.

With the equipment shown in fig. 2, the blower forces the vapor through a spreader tube that is fixed transversely below the front end of the dragsheet. Holes in the lower wall of the tube permit the vapor to be forced down among the plants. By admitting preheated air into the vaporizing pipes and admitting to the blower some unheated outside air, sufficient draft is created by the blower to

transport the vapor rapidly. Where too much air is admitted, the vapor is diluted to a sublethal concentration and, also, a pressure is created under the dragsheet, resulting in the forcing of the vapor through the fabric and from under the dragsheet at the front and sides.

The importance of the diffusion problem is reflected in the results obtained in treating tall, densely growing peas for aphids. The highest kill is obtained on the upper part of the plants where the insects receive the highly concentrated vapor directly from the spreader. The lowest kill is obtained near the ground where the insects are shielded by the dense growth of stems and foliage. In the treatment of orchard trees it is desirable to provide sufficient draft through the spreader so that the vapor rather slowly envelops the tree. When too much air is admitted to the blower, the vapor becomes excessively diluted and it is also driven through and beyond the tree.

PROBLEM OF CONDENSATION.—The boiling point of nicotine is 476° F. In passing through a spreader tube 10 or 20 feet in length, in the type of equipment used for treating field crops, the highly concentrated vapor becomes greatly cooled and more or less condensation occurs.

The machine described above has two special features for reducing loss from condensation. First, a strong blast of air preheated to about 500° F., used in atomizing the liquid nicotine, provides most of the draft that is needed to carry the vapors through the spreader. Second, the exhaust manifold of the gasoline engine opens into a cubical "vapor box" that incloses the discharge ends of the vaporizing pipes and also incloses the intake port of the blower.

The hot exhaust gases from the engine and the blast of preheated air, supplemented by the high temperature imparted by the vaporizing pipes, serve to heat the blower and spreader to a temperature sufficiently high to greatly reduce condensation. The vapor box is provided with a gate for admitting outside air where additional draft is deemed desirable.

TEMPERATURE SURROUNDING PLANTS.—Controlled experiments made with the codling moth and the common housefly, and experience in practical treatments made in the control of aphids, have shown that the killing efficiency of nicotine vapor is closely correlated with the temperature of the atmosphere surrounding the insect. This factor was found to be particularly important in the control of pea aphids in the winter and early spring months, the principal pea growing period in California. Much of the treating must be done when the atmospheric temperature is 60° to 70° F. Through the provisions above described for reducing condensation, it was found in certain tests that the atmosphere under the front portion of the dragsheet ranged from 2 to 45 degrees higher than that of the outside atmosphere, the higher temperature having been recorded with a thermometer fixed at a distance of 6 inches from a discharge port of the spreader. At times the spreader tube became hot enough to scorch the dragsheet in contact with it, and on one such occasion the vapors ignited, with the result that the dragsheet was burned up.

DRAGSHEET.—In the efficient use of nicotine dust in the control of aphids of field and truck crops, it has long been the practice to discharge the dust under a dragsheet. The use of a dragsheet is essential in obtaining control with nicotine vapor. Several types of dragsheet, as regards material and construction, have been used. The materials have included lightweight muslin, lightweight muslin lamellated with cellophane, 8-ounce army duck canvas, and "350 sheeting." The muslin was not sufficiently durable and it also permitted an excessive loss of vapor through the fabric. The muslin-cellophane had the advantage of being vapor tight and light in weight, but it lacked durability. The 8-ounce duck was too heavy and difficult to handle where used in dragsheets 60 feet and 100 feet in length. The "350 sheeting" was fairly satisfactory. This material has been used in making certain lightweight fumigation tents in southern California.

One end of the dragsheet is reinforced by a strip of canvas 3 feet wide. This reinforced portion bears grummets or snaps, set in a row 20 inches from the end margin, which serve for attaching the dragsheet to a boom of steel tubing that is fixed to the trailer chassis in front of the spreader. The 20-inch portion serves as a front curtain or flap. The dragsheet is sufficiently wide to drop to the ground

at each end of the boom and form side curtains. By this means the vapor is completely confined to the zone of the plants as the vaporizer advances. This particular principle has been recently described by Hales (1936), but it is not novel in insect control. It was described and illustrated by Horsfall (1924), and by Cory & Potts (1924). It was also utilized by Campbell (1923), who possesses original photographs showing the essential features of this type of dragsheet as used in his investigations.

A dragsheet 100 feet in length presents a difficult problem in the turning of the vaporizer at the ends of the field. Dragsheets 40 feet and 60 feet in length have been used in treating small fields, and have given good results where the effect of the shorter length has been offset by increasing the dosage of nicotine. The 100-foot dragsheets have been made in two sections, the front section 60 feet in length and the rear section 40 feet in length. The two sections are readily fastened together by means of rings and snaps. To facilitate the more effective use of the equipment under moderately windy conditions, the sides of the dragsheet and the free margin of the front flap are weighted by a chain or by small weights.

CONCLUSION.—It should not be inferred that the vaporizer described is a preferred design or that it is notably practical and efficient. On the contrary, it has some obvious shortcomings, the most im-0ortant being its complexity of parts and relatively high cost. These can probably be largely overcome by employing a heated coil to vaporize the nicotine, thereby dispensing with the air compressor and the atomizing mechanism. The necessity of providing a flow of heated air with which to convey the vapor to the plants and diffuse it among the plants will vary considerably with different conditions of insect infestation. Investigation may show that this feature may be dispensed with in most control work.—11-15-37.

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GRAPE VINES or cuttings showing evidence of *Phylloxera* infestation are prohibited entry into Washington, according to state quarantine order no. 25, effective November 1. Certification at origin is required on all shipments. Uncertified shipments are admitted only after treatment at destination.

AREAS covered in recent revisions of California and Georgia quarantines relating to the peach mosaic disease include 8 counties in Arizona, 3 in Colorado, 11 in New Mexico, 1 in Oklahoma and 2 in Utah, and the California proclamation applies to 25 counties in Texas, while the Georgia quarantine applies to but 24.

NOVEMBER quarantine action on the part of Mississippi extended the areas designated as infested with the sweetpotato weevil and issues a rule which prohibits the sale in that state of uncertified Irish potato seed for spring planting.

THE RECIPROCITY arrangement for nursery fees has been adopted in North Carolina, out-of-state nurserymen to be charged the same fee for shipping into North Carolina as that required of North Carolina nurserymen and dealers in such state. Free entry of nursery stock is allowed in the case of states requiring no registration fee.

THE ALABAMA quarantine relating to the sweetpotato weevil was revised on November 15 to designate a part of Conecuh County in that state as infested. The eradication area in that state has been extended to apply to any area in which there is sufficient reason to believe that the insect actually occurs.

THE WYOMING counties of Campbell, Johnson, Sheridan and Weston were added to the alfalfa weevil infested area in the South Dakota quarantine revised, effective December 1.

Toxicity of Several Stomach-Poison Insecticides to Four Species of Lepidopterous Larvae

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In the order Lepidoptera are many species which in the larval stage exact a heavy toll on cultivated crops. The damage caused by this group of insects is particularly severe in certain of the Gulf Coast states. Cultivated crops of some kind are grown throughout the year and, since the winters are rarely severe enough to destroy all these insect pests, some species are present in destructive numbers the year around.

Studies were undertaken to develop more effective methods for the control of several of the most destructive species occurring in Louisiana. During the course of the investigation, the relative toxicity of several commonly employed stomach-poison insecticides was determined for four species of these caterpillars. The median lethal dose (M.L.D.) was used as the measure of toxicity. Although the results obtained by laboratory methods cannot always be duplicated under field conditions, the information obtained in this manner is valuable in conducting field experimentation. The susceptibility of various species to stomach-poison insecticides can be accurately determined only by laboratory methods. With this information at hand, the problem of developing more effective control measures using insecticides can be attacked in an understanding manner.

A description of several changes in methods that have proved useful in determining the median lethal doses of stomach-poison insecticides is also given in this paper.

This investigation was conducted at the Louisiana State University between October 1, 1936, and October 1, 1937.

Materials.—Fifth instar larvae of the imported cabbage worm, *Ascia rapae* (L.), the cabbage looper, *Autographa brassicae* (Riley); the fall webworm, *Hyphantria cunea* (Drury); and the velvetbean caterpillar, *Anticarsia gemmatilis* (Hbn.) were employed. In all cases, the caterpillars were collected from their respective host plants several hours before the tests were made, thus insuring that they would feed when the tests were begun.

The insecticides used in these tests were fresh samples of proprietary products. The analyses of these are as follows:

Barium Fluosilicate.—This sample contained 72 per cent barium fluosilicate and 8 per cent sodium fluoaluminate (analysis on container).

Calcium Arsenate.—This sample was "regular" or "ordinary" calcium arsenate. It was analyzed and found to contain 43.35 per cent As_2O_5 and .34 per cent water soluble As_2O_5 by the A.O.A.C. method and 4.26 per cent water soluble As_2O_5 by the Geneva method.

Sodium Fluoaluminate.—This was found to contain 86.0 per cent sodium fluoaluminate. It is a neutral synthetic cryolite.

Lead Arsenate.—This sample was analyzed and was found to contain 31.55 per cent As_2O_5 and no water soluble As_2O_5.

Method.—In some of the tests, the single leaf method of Hansberry & Richardson (1936) for feeding measurable doses of stomach-poison insecticides to leaf-feeding insects was employed. In the remainder, certain modifications which permitted the more accurate evaluation of the relative toxicity of less toxic materials were used. There are two factors that limit the usefulness of the method of Hansberry & Richardson. First, when a heavy application of dust is made, which is necessary in the case of materials low in toxicity, the caterpillars dislodge some of the dust with their mouthparts and tarsi while feeding. Second, there are certain types of foliage to which even small quantities of some stomach-poison insecticides do not readily adhere.

In order to overcome these difficulties and thereby increase the usefulness of this method, experiments were conducted with several water-soluble nontoxic materials that would hold the dust particles securely to the foliage. The best results were obtained with a mixture composed of equal parts (by volume) of a .5 per cent blood albumen solution and a 5 per cent dextrin solution.

Leaf squares exactly 10 mm. square were used in order that the area consumed could be easily determined. A thin, uni-

form film of the sticker-spreader mixture was brushed on the upper surface of the leaf squares, and these and a piece of crosssection millimeter paper exactly 16 times as large were dusted under a large bell jar by the air-float method. The weight of the paper was accurately determined before and after dusting, and from the difference in weight the quantity of dust falling on each square millimeter of surface was calculated.

After the leaf squares were dusted, they were placed with the dusted side up in a petri dish containing a disk of moist filter paper. They were kept here until they were offered to the hungry caterpillars; then a square was picked up with a pair of small forceps and a pin was pushed through the center from the lower or undusted side. The mount was then inverted and the pin containing the dusted square was pushed into firmly packed, fine, moist sand (which was retained in a small box) so that the dusted side faced down and was about one-eighth inch from the sand. A small celluloid cup containing a larva was placed over the square and pushed slightly, but firmly, into the sand. The cups were placed about two inches apart and water was sprinkled on the sand about twice daily, or whenever needed. This moisture kept the leaf squares from shrinking.

The feeding caterpillars could be observed through the transparent cups, thus permitting the worker to remove them when they had eaten the approximate quantity of poisoned leaf desired. After the caterpillars had fed, they were weighed, numbered and deposited in celluloid cups containing fresh food, and then placed over moist sand for further observation.

The counting of the square millimeters of poisoned leaf consumed by each caterpillar was facilitated by using a simple device made as follows: A piece of crosssection millimeter graph paper was sealed between two pieces of celluloid with acetone. On this was superimposed another piece of celluloid out of which a 10-mm. square (the exact size of the leaf square) was cut. This was then sealed in place so that the cut-away square in the celluloid corresponded with the 10×10 mm. square on the paper. The mount was tacked on a wooden block to prevent it from curling.

The partly eaten leaf square was fitted into the mount and a strip of celluloid placed over it so that the leaf square would be held securely. The number of square millimeters of paper showing (representing the area eaten by the caterpillar) was counted with the aid of a binocular microscope. Then the quantity of poison consumed by each caterpillar (milligrams of poison per gram of insect body weight) was calculated.

Larvae used in these tests were retained on fresh food for 72 hours after having been fed on the poisoned leaf squares, or longer if they had not resumed normal feeding or had not died at the end of this time. It was our experience that larvae which were feeding normally in 24 hours after having ingested dosages of our commonly used stomach poisons invariably recovered; and those which had neither died nor recovered in from 24 to 48 hours might either die, or resume feeding later and recover. This fact has been taken advantage of in later work, and the larvae are considered as having recovered after resuming normal feeding. Larvae, especially those of *Ascia rapae* fed on cryolite, may go several days without either resuming feeding or dying. In some cases, we have observed such larvae that had shrunk in size to at least one-half of their original body weight, then resume feeding and recover.

In general, the average time to kill, of all of these materials on the various insects used, ranged between about 20 to 48 hours. In all cases true death was used as the endpoint.

DISCUSSION OF RESULTS.—The results of these experiments are given in table 1. Check caterpillars were run with the treated. The natural mortality was low in all cases, but this was taken into account when determining the median lethal dose. The caterpillars were examined before the tests were made and any that appeared to be parasitized or diseased were discarded.

The information in table 1 is not extensive enough to allow comparisons between all of the compounds tested on all four species of insects represented, but two interesting comparisons can be made.

The first thing to be noticed is the difference in susceptibility of the various species involved to a given poison. In the case of sodium fluoaluminate, the M.L.D.'s for *Ascia rapae*, *Autographa*

brassicae, *Hyphantria cunea* and *Anticarsia gemmatilis* are .68, .42, .45, and .17 mg./g. respectively. It may be seen, therefore, that this compound is four times as toxic to *Anticarsia gemmatilis* as to *Ascia rapae*, and that the toxicity to *Autographa brassicae* and *Hyphantria cunea* is intermediate between these two extremes.

Since the M.L.D. of barium fluosilicate was determined only for *Ascia rapae*, no comparisons can be made with this material.

The M.L.D. of acid lead arsenate was determined for two species, *Ascia rapae* and *Anticarsia gemmatilis;* the M.L.D. for the former was .09 mg./g. (with a sticker), and .12 mg./g. for the latter. This material, therefore, exhibits very little difference in toxicity to these two insects. As is shown in table 1, the M.L.D. of acid lead arsenate for *Ascia rapae* was determined both with and without the sticker-spreader material. The M.L.D. without the sticker is .10 mg./g. with an intermediate range of .07 to .14 mg./g. and with the sticker is .09 mg./g. with a range of .07 to .12 mg./g. It is realized that if these data were analyzed statistically, probably no differences would be revealed, but an examination of the caterpillars under a binocular microscope while they were feeding showed that some of the dust particles were dislodged when no sticker was used. It was also observed that when poisons of less adhesiveness than acid lead arsenate were used, and when poisons of less toxicity were tested, necessitating a heavier application of dust, an even larger amount of the poisons was dislodged by the caterpillars.

A comparison of the M.L.D.'s of calcium arsenate to the four species of caterpillars reveals very large differences in susceptibility of the individual species to this poison. Calcium arsenate was the most toxic to the noctuid, *Anticarsia gemmatilis*, with an M.L.D. of .11 mg./g., and the least toxic to the arctiid, *Hyphantria cunea*, with an M.L.D. of about 2.0 mg./g. In fact, the toxicity to the latter insect was so low that it was difficult to obtain an M.L.D. The M.L.D. of calcium arsenate to *Autographa brassicae* and to *Ascia rapae* was .50 mg./g. and .74 mg./g., respectively.

Next, comparisons can be made between the toxicity of the various compounds to a given species of insect. Here, also, large differences are shown. In the case of *Ascia rapae*, the M.L.D. of sodium fluoaluminate is .68 mg./g., of barium fluosilicate .43 mg./g., of acid lead arsenate .09 mg./g., and of calcium arsenate .74 mg./g. Acid lead arsenate, therefore, is about four to eight times as toxic to this insect as any of the other poisons which were tested.

The information on *Autographa brassicae* is too meager to permit good comparisons, but it appears that sodium fluoaluminate and calcium arsenate have about the same toxicity to this insect.

The M.L.D.'s of sodium fluoaluminate

Table 1.—The M.L.D. of several stomach-poison insecticides to four species of lepidopterous larvae.

POISON	INSECT	NO. OF INSECTS IN THE INTERMEDIATE ZONE	DOSAGE RANGE mg./g. of body weight	M.L.D. mg./g. of body weight
Sodium fluoaluminate	*Ascia rapae*	101	0.33–1.05	0.68
Sodium fluoaluminate	*Autographa brassicae*	32	0.25–0.77	0.42
Sodium fluoaluminate*	*Hyphantria cunea*	75	0.32–0.74	0.45
Sodium fluoaluminate*	*Anticarsia gemmatilis*	57	0.09–0.25	0.17
Barium fluosilicate	*Ascia rapae*	69	0.34–0.67	0.43
Acid lead arsenate	*Ascia rapae*	81	0.07–0.14	0.10
Acid lead arsenate*	*Ascia rapae*	67	0.07–0.12	0.09
Acid lead arsenate*	*Anticarsia gemmatilis*	100	0.06–0.20	0.12
Calcium arsenate	*Autographa brassicae*	39	0.33–0.66	0.50
Calcium arsenate*	*Anticarsia gemmatilis*	124	0.08–0.21	0.11
Calcium arsenate	*Ascia rapae*	70	0.60–1.04	0.74
Calcium arsenate*	*Hyphantria cunea*	192	0.42–4.77	2.00

* Spreader-sticker material was used.

and of calcium arsenate were determined for *Hyphantria cunea*, and it was found that the former poison is about four times as toxic to this insect as is the latter.

Of the three poisons tested on *Anticarsia gemmatilis*, sodium fluoaluminate gave an M.L.D. of .17 mg./g., acid lead arsenate an M.L.D. of .12 mg./g. and calcium arsenate an M.L.D. of .11 mg./g. Although acid lead arsenate was much more toxic to *Ascia rapae* than sodium fluoaluminate and calcium arsenate, the three poisons have about the same toxicity to *Anticarsia gemmatilis*.

SUMMARY.—Several changes in technique of determining M.L.D.'s by the single leaf method of Hansberry & Richardson are described. A sticker-spreader mixture for holding the dust particles to the foliage was used in some of the tests. A total of 11 M.L.D.'s was determined, representing four different stomach-poison insecticides and four species of lepidopterous larvae. It was shown that there was a marked difference in the susceptibility of the various species of insects to the several poisons employed, and also that a great difference existed in the toxicity of the several poisons to a given species; e.g., the M.L.D. of sodium fluoaluminate was .68 mg./g. for *Ascia rapae* and .17 mg./g. for *Anticarsia gemmatilis*, whereas acid lead arsenate exhibited about the same toxicity to both species. The M.L.D. of calcium arsenate varied from .11 mg./g. for *Anticarsia gemmatilis* to about 2.00 mg./g. for *Hyphantria cunea*.—11-4-37.

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Wetting Properties of Triethanolamine Oleate

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Triethanolamine oleate is widely recognized to be an efficient emulsifying agent, and as such it finds extensive use in the preparation of technical emulsions such as polishes, pharmaceuticals, cutting oils, cosmetics, and cleansing and shaving creams. It is also used in the preparation of mineral-oil emulsions for orchard sprays, and for this purpose it is claimed to possess certain advantages over the ordinary alkali-metal soaps.

One important advantage is that it is readily soluble in both water and oils. Sprays made up with triethanolamine oleate as emulsifying agent are said to produce even wetting of the leaf and deep impregnation of the insect, with the added advantage of a low alkalinity which should cut down much of the "burning" of foliage encountered after sprayings (Wilson 1930).

Triethanolamine oleate is also used with mineral oil and lead arsenate or calcium arsenate in the so-called "dynamite" arsenate mixtures which are used to some extent in the Northwest (Marshall & Groves 1937). In these sprays the arsenate is carried by the oil instead of by the water, and the triethanolamine oleate possibly functions as a deposit builder and sticker as well as a wetter.

This paper presents the results of an investigation of the wetting properties of aqueous solutions of triethanolamine oleate, over a range of concentrations and with varying ratio of base to fatty acid, which makes possible a comparison between the wetting properties of this soap and those of the caustic alkalies.

EXPERIMENT.—The wetting power of a liquid, A, for the surface of a liquid, B, is a function of three distinct surface (or interfacial) tensions, T: (1) the surface tension of liquid A, (2) the surface tension of liquid B, and (3) the interfacial tension between liquids A and B. This wetting power has been given the name "spreading coefficient" (Harkins & Feldman 1922) and is here represented by the symbol S. The relation is expressed mathematically as follows:

$$S = T_B - T_A - T_{AB}.$$

The spreading coefficient, as thus defined, has been found to be an accurate

measure of the wetting power of one liquid for another liquid surface. The same general relations apply in the consideration of the wetting power of a liquid for a solid surface, but greater difficulties are encountered in the measurement of the interfacial tension between the liquid and the solid, and it is extremely difficult to find a solid surface that has experimentally reproducible surface characteristics (Bartell *et al.* 1936). For these reasons the spreading coefficient over a highly refined mineral oil has been chosen as a measure of wetting power for the present investigations. Although each type of surface may be expected to have its individual surface characteristics, it is believed that this measure of wetting power will indicate, in a general way, the wetting power of the solutions for surfaces

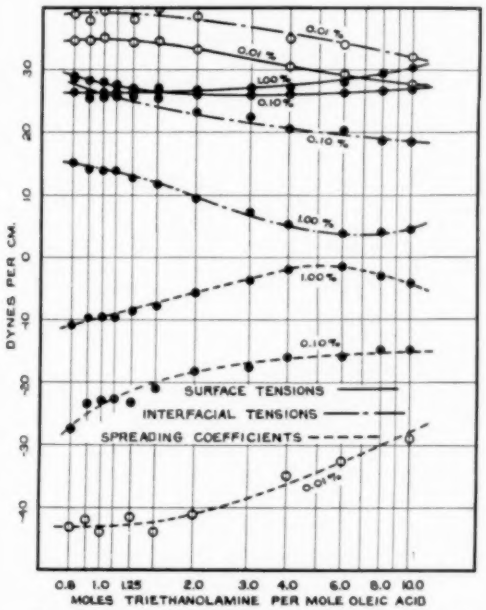

FIG. 1.—Variation of wetting properties with the base-acid ratio, for triethanolamine-oleic acid mixtures in water, at concentrations of 1.0, 0.10 and 0.01 grams oleic acid per 100 cc.

that are relatively difficult to wet with water. The experimental methods have been previously described (Cupples 1935).

DISCUSSION.—Fig. 1 shows the variation of wetting properties with the base-acid ratio at the concentrations 1.00, 0.10 and 0.01 per cent oleic acid. There are no inflections of the curves in the vicinity of the molar ratio 1.0, such as are found when the base is a caustic alkali. The curves more nearly resemble those obtained by the writer (1936a, 1936b) with the alkali metal carbonates. All the solutions readily produced a stable foam on moderate shaking.

At the concentration of 1.0 per cent, the surface tension increases slowly with increase of the base-acid ratio throughout

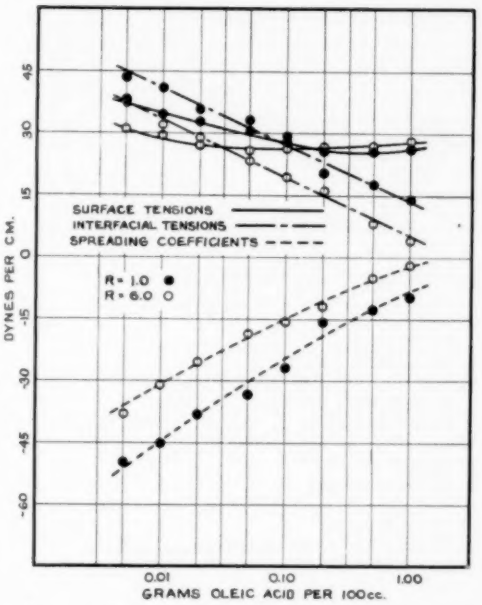

FIG. 2.—Variation of wetting properties with concentration, for triethanolamine-oleic acid mixtures in water, at base-acid ratios (R) of 1.0 and 6.0.

the range studied; the interfacial tension decreases to a minimum at a ratio of about 6.0, with a slight rise beyond this point; the spreading coefficient increases with the base-acid ratio up to a ratio of about 6.0, and decreases thereafter.

At the concentration of 0.10 per cent the surface tension decreases with increase in the base-acid ratio up to a ratio of about 2.0, and then increases slightly; the interfacial tension decreases with increase in the base-acid ratio throughout the range studied; the spreading coefficient increases with the base-acid ratio throughout the range studied, but only slowly above the ratio 4.0.

At the concentration of 0.01 per cent the surface and interfacial tensions are substantially constant between the ratios 0.8 and 1.50, and then decrease with further increase of the base-acid ratio; the

spreading coefficient remains practically unchanged between the ratios 0.8 and 1.50 and then increases throughout the range studied. The forms and general relations of the curves are such as might be expected with mixtures of oleic acid and a very weak base, from analogy with the behavior of mixtures containing the carbonates and hydroxides.

Fig. 2 shows the variation in wetting properties with concentration at the two base-acid ratios (R) 1.0 and 6.0. Concentrations are here expressed in grams per 100 cc., which is equivalent to the percentage. The mixtures containing the larger amount of triethanolamine have superior wetting properties throughout, except that these mixtures have slightly higher surface tensions at concentrations of 0.2 gram per 100 cc. and above. On this plot, concentrations are plotted on a logarithmic scale, and it is interesting to note that, for both values of R, the interfacial tension is approximately a straight-line function of the logarithm of the concentration.

SUMMARY.—At concentrations from 0.01 to 1.00 per cent oleic acid the wetting power of aqueous triethanolamine-oleic acid mixtures increases with increase of the ratio of triethanolamine to oleic acid, at least up to the mole ratio 6.0. At moderately high concentrations, such as 1.00 per cent oleic acid, there is no abrupt change in wetting properties in the vicinity of the ratio 1.00 (point of equivalence), such as occurs when the base is a caustic alkali. Solutions of triethanolamine oleate readily produce a stable foam, and the material has a number of desirable properties which make it an efficient wetting agent.—11-15-37.

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Methyl Bromide—Its Expectancy as a Fumigant

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Methyl bromide was first used in California for insecticidal purposes during 1935. Since then it has been used successfully in the solution of a number of entomological problems of widely varying natures. In this paper are presented data assembled from a number of sources during two years of investigation of its properties, designed the better to estimate its expectancy in this field.

PROPERTIES.—Methyl bromide, CH_3Br, is a colorless liquid which boils at 4.5° C. or 40.1° F. Its molecular weight is 94.95 and its specific gravity is 1.732. At ordinary temperatures methyl bromide is a gas, one pound of which occupies 3.98 cubic feet. Compared with air, its specific gravity is 3.50. Its vapors have an odor, slightly persistent, approaching chloroform. It is only slightly (trace) soluble in water.

HISTORY AND USES.—Methyl bromide was reported by Perkins in 1884. Its early use was in the medicinal field.

Since its discovery, its widest use has been for the preparation of methyl compounds used in the manufacture of aniline dyes. With the development of com-

* Early publication of this paper has been secured by payment of the printing charge.

mercial aviation, methyl bromide has attained considerable popularity as a fire extinguishing agent.

Its insecticidal properties were first reported by Le Goupils (1932), an entomologist of the French government, who, in 1931, noted its insecticidal properties. These led to the treatment of grain to destroy granary weevil. Paul Vayssière (1934) further reported on its insecticidal properties. J. de Francolini (1935) made extensive tests with both milling grains and living plants. He also reported on hydrolysis.

André Lepigre (1936) gave a most interesting dissertation on its possible uses and effects on cereal grains, and on himself.

All of the French entomologists show great insight into factors which might influence the future status of methyl bromide as a fumigant.

By fortuitous circumstances, I have had the good fortune of intermittently corresponding with M. Vayssière for over 15 years on matters pertaining to vacuum fumigation, and with M. Lepigre for about half that time, though it was not until 1936 that I received a translation of their excellent papers. These have been a major cause of my own efforts. I believe that the results obtained by the French investigators have provided the stimuli to all investigators in this country.

In the United States, methyl bromide, though now used alone, was first mixed with carbon dioxide and the mixture still is sold under a proprietary name. This mixture was utilized by the writer until a proper dispenser could be designed and constructed that would permit using the pure article.

My immediate concern was to secure a fumigant less violently combustible and injurious to potatoes, but equally lethal to certain pests attacking them. Its use as a fumigant to treat dried fruit was investigated at the same time by Charles D. Fischer, the entomologist of the Dried Fruit Association of California.

My greatest interest has been in the application of methyl bromide to a number of problems in so-called quarantine entomology, in the hope of providing a greater freedom of movement for many products under regulation because of their hazard as carriers of certain insects. In 1936 I visited the Washington, D. C., and Ottawa, Canada, Departments of Agriculture, as well as the manufacturers of methyl bromide, presented my limited data and suggested an exploration of the possibilities of this compound in treating commodities to destroy Japanese beetle, European corn borer, oriental fruit moth and a number of other pests.

The advantages of such a collaboration over individual investigation are obvious.

1. It would bring about investigation over a much wider field.
2. It would develop the insecticidal possibilities at an earlier date.
3. It would minimize the hazard of autosuggestion that often accompanies the lone worker.
4. It would improve the technique in its application.

Such a course has been more than justified. At this writing, an exchange of data has been affected with entomologists of other states, with officials of the Federal Entomological Service, of the United States and Canada, and of the Territory of Hawaii, the Philippines, France, Algeria, Morocco and Australia.

METHODS OF APPLICATION AND FORMULAE.—Five different formulae and methods have been used in applying methyl bromide.

In the first, the so-called vacuum fumigation method, the fumigant is injected simultaneously with the gases of the atmosphere into a chamber in which a partial vacuum (5 inches to 27 inches merc. vac.) has previously been created; this is followed by exposure at atmospheric pressure for 90 minutes.

In the second method, the fumigant alone is injected in a partial vacuum and the exposure to the fumigant made at subatmospheric pressure. The exposure is 90 minutes. This latter method requires a chamber where there is no leakage.

In the third method, the period of exposure to the fumigant is made at atmospheric pressure. For the more protracted period of two to three hours, the dosage factor is the same as in the first two methods.

The fourth method is like the third, except that the dosage is reduced materially, say to 4 ounces per 1,000 cubic feet, and the exposure is lengthened to 16 hours.

In the fifth method, a small, measured dosage is merely injected in the domicile

of the pest and left to complete its lethal action.

To obtain some idea of the broad field of the utility of methyl bromide, it is necessary to divide the commodities according to their individual peculiarities. The tolerance of living plants or plant products to the vapors of methyl bromide, either in vacuum or atmospheric fumigation, lends weight to the belief that the list of plants and products that can be treated successfully may be greatly increased over that treated with the present known group of fumigants.

FACTORS INFLUENCING INSECTICIDAL ACTION.—The insecticidal action of methyl bromide is not completely understood. Seemingly its action is toxic rather than narcotic, and, after entering the system, it changes, forming secondary compounds that bring about death. The fact that insects are alive and active often after exposure to its vapors, though they invariably die, supports the belief of secondary action. Whatever course its lethal action may take, observations indicate it is not a quick acting fumigant but exhibits greater lethal efficiency as exposure to its fumes becomes more protracted.

Used under these conditions, such factors as temperature, which affect its lethal action to a large degree on 90 minute cycles, progressively decline and disappear as the cycle of exposure is lengthened. Except at vastly increased dosages, to which many products are intolerant, it seldom can be used at exposures of less than 90 minutes.

Fans in fumigation chambers tend to prevent stratification, accelerate its diffusion and provide for early equilibrium.

TREATMENT OF FRUITS AND VEGETABLES.—Following is a list of fruits and vegetables that have been treated either experimentally or under industrial conditions at dosages completely lethal to some of their major insect pests. Opposite each fruit or vegetable is the insect pest or pests for which control is sought.

Potatoes (375 cars)	Tuber moth
Tomatoes (10,000 cases and 8 cars)	Pin worm
Pears, 2 varieties	Codling moth
	San José scale
Green beans	Japanese beetle*
Green corn	European corn borer†
Peaches	Peach twig borer
Artichoke	Plume moth
Avocado	Latania scale
Celery (6 cars)	Vegetable weevil
Cauliflower	Cabbage worm
Turnip	Seed-corn maggot
Sweet potato	Sweet potato weevil
Persimmon	Mealybug

* Hawkins, 1937.
† McLean, 1936.

I am informed that a limited number of cars of green vegetables have been treated successfully to destroy adult Japanese beetle.

In an exchange of data with Canadian entomologists, it is reported that the corn borer in the larval stage is killed by vacuum fumigation, as is the larva of the apple maggot.

TREATMENT OF HERBACEOUS PLANTS.—In the following list are examples of herbaceous plants that were tolerant to vacuum fumigation at dosages lethal to the mealybugs, *Pseudococcus maritimus* (Ehrh.) and *Rhizoecus terrestris* (Newst.), and to the cyclamen mite, *Tarsonemus pallidus* (Banks):

Ferns	Pansy
Begonia Rex	Strelitzia
Begonia Incarnata	Musa
Cyclamen	Cactus (Christmas)
Coleus	Strawberry plants

TREATMENT OF PALMS.—A list of the palms treated includes Kentia, Areca and Phoenix. The dosage applied—2.5 pounds per 1,000 cubic feet—is fatal to the ground mealybug, *Rhizoecus terrestris*, to the palm scales, *Diaspis boisduvali* and *Aspidiotus cyanophylli* and to greedy scale, *A. camelliae*.

TREATMENT OF WOODY PERENNIALS.—The treatment of woody perennials has assumed the status of industrial application. In most cases they are put through the vacuum fumigators as they come, without regard for species.

A wide range of pests is carried, largely Coccids, of which there are some fifteen species included. Generally the dosage is 2.5 to 3.5 pounds, according to the temperature. Of the so-called dormant stock that is largely treated on bare roots, no damage has been incurred at these doses. Though several thousand trees have shown a great degree of tolerance, it is desired to develop further data, particularly as to hosts of the oriental fruit moth.

TREATMENT OF ORCHIDS.—The successful application of any treatment to orchids is hampered by a number of factors such as (1) the condition in which

they arrive, (2) the variety of pests that infest them, (3) their wide diversity of growing habits, (4) the difference in their foliage texture and the presence or absence of essential oil in their foliage. Some tests have been run with orchids in an active state of growth.

A diversity of results has been obtained; for example, in both *Phalaenopsis* and *Cypripedium* some plants given vacuum fumigation at 3 pounds for 90 minutes, injected at 20-inch partial vacuum, showed no injury, while others that received only 1 pound were killed. This indicates a wide difference in the individual plant vitality.

A wide range of orchids has been treated as a condition of entry, including some 3,700 plants belonging to 12 different genera.

While the question of plant tolerance remains unsettled, it is fairly well established that a dosage of 3 pounds per 1,000 cubic feet in a 20-inch partial vacuum is lethal to the snout beetles, *Orchidophilus* and *Diorymerellus*, and the coleopterous leaf miner, *Mordelestinus*, together with a considerable number of Coccid species, including mealybugs. The exposure should be for 90 minutes at 65° or over.

TREATMENT OF STORED PRODUCTS.—For convenience, insects infesting stored products are divided into those attacking grain and those attacking dried fruit.

The two primary species of the former are granary weevil, *Sitophilus granaria* (L.), and the Angoumois grain moth, *Sitotroga cerealella* (Oliv.). A dosage of 1 pound per 1,000 cubic feet of grain, applied under gas-tight tents for 12 hours or over proves 100 per cent lethal to all stages of both species. The best usage calls for an air dome at the top to permit better diffusion. In one instance of this kind, no emergence has taken place and more than 150 days have elapsed since this treatment.

The same dosage and exposure have been equally effective on the secondary species, *Tribolium* and *Orizophilus*, and against all stages of the genera, *Ephestia* and *Plodia*. It has been applied at this schedule under a wide range of conditions, including warehouses, refrigerator cars, flour mills and elevators under fumigation tents and vacuum fumigation.

TREATMENT OF DRIED FRUITS.—More methyl bromide is used in treating dried fruit than in any other field. The same dosage schedules were applied as for grain, and have been equally effective against the raisin moth, *Ephestia figulilella*(Greg.), the Indian-meal moth, *Plodia interpunctella* (Hbn.) and a number of secondary pests of grain such as *Tribolium* and *Orizophilus*.

It is believed that in the current season the tonnage treated by methyl bromide exceeds that of all other fumigants combined. The popularity of this fumigant was developed by Charles D. Fischer, Entomologist for the Dried Fruit Association of California, and the late J. C. Maxcy, than whom there were few men better informed in the control of pests of stored products.

TOLERANCE OF INSECTS TO VAPORS.—From time to time specific resistance to methyl bromide is noted in some species of insects, or lack of tolerance to its vapors is noted among plants, but this is to be expected, because of its fat solvent properties. For example, the oil cells in the rinds of citrus fruit react in the presence of its vapors, probably absorbing it, which phenomenon manifests itself in a russeting that appears after about ten days.

Some members of the order Thysanoptera seem to possess a resistance unexplainable at present. Though some species are killed by long exposures to a comparatively low dosage, they are not killed by the ordinary two-hour exposure that will kill many other species. Some Coccid eggs seem to possess resistance, though this may be traceable to mechanical considerations.

Other insects seem to be particularly susceptible to the vapors of methyl bromide. Among these are codling moth larvae, which, even though deep in their burrows in the center of pears, succumb to a dosage of one-half pound of methyl bromide per 1,000 cubic feet of space. San José scale yields to a dosage of one-fourth pound per 1,000 cubic feet for 16 hours.

INSECTS AFFECTING MAN AND ANIMALS.—The recent work of Dr. M. A. Stewart of the University of California with insect vectors of bubonic plague, that can carry the disease for a considerable period independent of their intermediate rodent hosts, creates a new aspect in the control of plague. Where the

control of the parasites of the rodents formerly was incidental, it now becomes primary.

The lethal effects of methyl bromide on fleas and other rodent parasites as compared with other fumigants is the subject of a paper under preparation by Dr. Stewart and the writer. Doses sufficient to destroy rodent plague carriers also destroy the insect vectors of the disease.

The use of methyl bromide in the control of insect vermin affecting man has been limited to the bedbug, *Cimex lectularis* (L.). In dosage of 1 pound per 1,000 cubic feet at atmospheric pressure for 16 hours, it has proved entirely lethal when applied to crew quarters on shipboard. Under vacuum fumigation, exposures of 90 minutes are likewise lethal, though death is delayed several hours. Methyl bromide has attained industrial status in connection with the control of bedbugs.

RODENT CONTROL.—The Rodent Control Service of the California State Department of Agriculture, under W. C. Jacobsen, has carried on very extensive tests for over a year, and reports that dosages of 9 to 10 cc. per burrow are uniformly lethal to the ground squirrel, *Citellus beecheyi beecheyi*, whether the squirrels are in hibernation or active. It is equally lethal to a wide range of fauna that may be temporarily domiciled in the squirrel burrow at the time of treatment. A list of the species killed includes rabbits, skunks, gophers, field mice, salamanders, frogs, grasshoppers and plant bugs. Details of the department's activities in this connection are in preparation for publication and probably will appear in the annual report.

Because of a low coefficient of adsorption, such factors as soil texture and moisture exert only slight influence on diffusion of methyl bromide, and it passes through the usual obstacles, such as soil plugs, that exist in most burrows.

It is equally effective in treating rat burrows. Though a specific dosage schedule has not been developed for this purpose, it is less than that used to destroy the aforementioned species. Rats confined in a jar having a capacity of 1 cubic foot, exposed to the fumes of 1 cc. of methyl bromide, died after 42 minutes of exposure; they succumbed to .5 cc. in 144 minutes. Exposure to methyl bromide fumes seems to depress the rat and causes no panic or effort to escape. Seemingly there is a paralysis followed by fatal coma.

TERMITES.—The idea of destroying termites by means of fumigants is not new, though it has never been popularized.

The specific gravity of gaseous methyl bromide, 3.50, plus the fact that it has fire extinguishing properties, suggested testing its possibilities in destroying colonies of the subterranean termite, *Reticulitermes hesperus* (Banks) in 1937.

In these preliminary tests, a measured dosage of the liquid was injected into the larger runways. The resulting heavier than air gas settles down in the passages and eventually reaches into the colony headquarters where it diffuses, killing the colony. The soil under a high school, having an area of 300 feet by 75 feet, and showing radiating passages leading from subterranean habitations to feeding places in 160 different locations in the school structure, was the object of treatment. All passages may not have represented separate colonies. The covered passageways were traced to the point of confluence. Into each passage, 10 cc. of methyl bromide was injected, the passage rubbed off and the place marked. Of the 160 applications made in this manner over a four month period, in only three cases have new passageways been erected. These may be small untreated colonies, which at that time were not connected with the passage tubes. No alate brood emerged with the fall rains.

EFFECTS ON SEED GERMINATION.—Tests on the effects of fumigation with methyl bromide on the germination of seed grains, plants, seeds, etc., are limited to barley, wheat, peanuts, carrots, beans, turnips and lettuce. All tests were made by California's State Seed Testing Laboratory. Results are given in table 1.

RESIDUAL CONSIDERATIONS.—As one might expect, the question of deleterious residues from treatment with methyl bromide has been presented. To date, the only information available consists of a series of analyses expressed as bromine only. They are interesting largely by reason of the small amount of residue that remained after treatment. I am informed that the United States Bureau of Entomology and Plant Quarantine already has under way a project on deleterious residues from methyl bromide.

The question of showing the particular form in which the residual bromines appear is complicated by the infinitesimally

small percentage that is found. The opinion expressed by several analysts interrogated on this subject is that these residues would appear as inorganic salts of bromine, varying with the basic elements with which they combine. They may be expected to appear as sodium, potassium, magnesium or calcium bromide, and as such would be harmless. Results of two investigations are shown in tables 2 and 3.

Table 1.—Results of seed germination tests with methyl bromide.

Crop	Vacuum (inches)	Cycle of Exposure (hours)	Dosage (Pounds per 1,000 cubic feet)	Length of Test (days)	Germination Treated (per cent)	Germination Controls (per cent)
Barley	27	1½	1.75	7	95	
Barley	27	1½	2.45	7	97½	
Wheat	—	—	—	7		88½
Wheat	27	1½	1.75	7	91½	
Wheat	27	1½	2.45	7	89	
Barley	—	—	—	7	—	99
Barley	0	24	1	7	94	
Barley	—	—	—	7		91½
Barley	—	—	—			100
Peanut	0	60	3.50	10	36	36
Barley	0	18	1	6	99	
Barley	—	—	—	6		100
Barley	0	24	1	6	99	
Barley	0	30	1	6	100	
Barley	0	36	1	6	98	
Barley	0	42	1	6	100	
Barley	0	48	1	6	100	
Carrot	27	1½	2.50	14	67¼	
Carrot	—	—	—	14		64½
Beans	—	—	—	13		92
Beans	27	1½	2.50	13	97	
Turnip	—	—	—	5		98½
Turnip	27	1½	2.50	5	98¾	
Lettuce	—	—	—	6		92½
Lettuce	27	1½	2.50	6	95	

Table 2.—Bromine found in samples submitted by the Entomology Branch, Department of Agriculture, Dominion of Canada, after treatment with "Proxate"; controls untreated. Figures express the amount of bromine in parts per million.*

	Treated Samples Ashed	Treated Samples Extracted by Boiling	Controls Untreated Ashed
Potato	19	19	7
Pea	17	17	4.5
Cabbage	15	15	1 or less
Cauliflower	15	15	2
Tomato	6	—	less than 1
Tomato Juice	6	—	—
Onion	1.5	1	—

* From V. Kitts, Senior Dominion Analyst.

EFFECTS ON MAN.—The effect of the vapors of methyl bromide on man is of primary interest. Its position in this regard is controversial as to exposure and dosage. Many persons have written on these questions and a large number of cases have been reported, but these do not always represent first hand information. Often the reporter shows no evidence of having had experience with this compound. Neither is any mention made as to its impurities. For this reason, I am confining quotations to authors presenting evidence of actual experience.

Public Health Service Report.—Investigators of the United States Public Health Service (1929) report the following:

"Methyl bromide, however, is a little more toxic than gasoline, chloroform and carbon tetrachloride for very short exposures and is markedly more toxic than these compounds in exposures of 30 minutes or more. That these alkyl halides should be found less toxic than gasoline was somewhat surprising to the authors, and a later study will be made of gasoline under conditions comparable to the experiments described in this report.

"In general these alkyl halides are markedly less toxic than the compounds which are usually termed poison gases, such as ammonia, carbon monoxide, hydrocyanic acid, hydrogen sulphide, chlo-

rine, phosgene, etc. However, for exposures of several hours, methyl bromide increases in relative toxicity and approaches that of some of the familiar poisonous gases. Also, since it is not unpleasant and but faintly noticeable in small amounts, it probably presents a greater hazard than some of the toxic

"Cubic feet of air in room, about 600. Cubic feet of methyl bromide in room, about 30. Cubic feet of space, four inches from bottom of floor, about 22. Methyl bromide gas is $3\frac{1}{2}$ times as heavy as air.

"Effects: Pulse normal after 20 minutes of exposure. Respiration normal after 20 minutes of exposure. Cold feet from drop

Table 3.—Bromide residues remaining in dried fruits after fumigation with methyl bromide. Residue is calculated as percentage of bromine. To convert to percentage methyl bromide, multiply by 1.19. Percentages given, except in experiments no. 1 and no. 5, represent increase in residue, due to fumigation, over that present in original untreated fruit.*

Exp. No.	Preparation of Sample	Details of Fumigation				Percentage Residue			
		#CH_3Br/ 1,000 ft.³	Temp. F.	Time	Pressure	Peaches	Raisins	Figs	Prunes
1	As received		Not fumigated			.00039	.00039	.00088	.00043
2	As received	$2\frac{1}{2}$	46°–51°	24 hr.	Atm.	.0007	.00004	—	—
3	As received	$2\frac{1}{2}$	110°	24 hr.	Atm.	.0014	.0079	.0067	.00069
4	As received (fumigated by Fischer)	1	?	?	Atm.	.0019	.00026	.00063	.00022
5	Soaked in water;† air dried 16 hr.		Not fumigated			.00038	.00039	.00081	.00037
6	Soaked in water;† air dried 16 hr.	$2\frac{1}{2}$	46°–51°	24 hr.	Atm.	.0017	.00058	.0017	.00047
7	Soaked in water;† air dried 16 hr.	1	46°–51°	24 hr.	Atm.	—	—	.0011	.0003
8	Soaked in water;† air dried 16 hr.	$2\frac{1}{2}$	110°	24 hr.	Atm.	.0048	.0031	.006	.0027
9	Soaked in water;† air dried 16 hr.	1	110°	24 hr.	Atm.	.004	.0012	.0033	.0011
10	Soaked in water, air dried, held 5 days in refrigerator and 4 hrs. at room temp. after fumigation	$2\frac{1}{2}$	46°–51°	24 hr.	Atm.	.0016	.00041	—	—
11	Soaked in water, air dried, held 5 days in refrigerator and 4 hrs. at room temp. after fumigation	1	46°–51°	24 hr.	Atm.	.00093	.00036	—	—
12	Same as no. 10, but held for 18 hrs. at 110° F. after fumigation	$2\frac{1}{2}$	46°–51°	24 hr.	Atm.	.0018	—	—	.00046

* Analyses by Dow Chemical Company; fumigation by Charles D. Fischer.
† Peaches soaked 10 min., others one-half hr.

gases possessing distinct warning properties."

Henning's Report.—Albert Henning (1933) gives his experience as follows:

"1921.—Half a gallon of methyl bromide ($8\frac{1}{2}$ pounds) was spilt on the floor of a waiting room of dimensions 11 feet by 6 feet by 9 feet. Three people, including myself, were present and the doors were opened. We remained 20 minutes, from 11:46 a.m. to 12:06 p.m. Two people sat down most of the time, but we did not always remain motionless. Lighted matches went out about four inches from the floor.

of temperature. Room temperature was 56 degrees F. (about 13.5 degrees C.). I had a drink of half-and-half whiskey afterwards but there were no intoxicating effects.

"1925 laboratory test.—A test was made to discover any signs of being affected with coughing, headache, anaesthetic symptoms, etc., in a small laboratory of dimensions 12 feet by 10 feet by 9 feet, with two men and two women present. For about a quarter of an hour methyl bromide was poured on to a lighted gas fire, which, of course, had to be repeatedly re-lighted. Whitish fumes

arose and clung around the ceiling and down to within a foot of the ground. All doors and windows were shut but no one felt any inconvenience and there were no after effects. The experiment was carried out at about 2:30 p.m., after the midday meal."

California Reports.—The following incidents are furnished in connection with the investigations of the California State Department of Agriculture on methyl bromide:

1. While filling a small dispenser with methyl bromide from a large cylinder, the cylinder rolled and the stream from a one-fourth inch pipe sprayed liquid methyl bromide into the eyes, nose and mouth of my assistant, who held his breath, walked to the water faucet and washed his face. No ill effects resulted, no chemical burns to eyes, nose or mouth and no after effects.

2. An operator experimenting with methyl bromide on rodents worked for seven hours over a leaky applicator. At the close of the day, he placed the dispenser in a closed automobile and was exposed to fumes for over 30 minutes. He had a headache, but ate his dinner. Afterwards he was seized with nausea which resulted in vomiting. He suffered from slight dizziness for three days.

3. Approximately 300 pounds of CH_3Br were used to fumigate a large mill, 300,000 cubic feet. A watchman entered to ring the time clock; walked 150 feet in building under fumigation, rang clocks on floor, went up one flight of stairs, rang clocks on next floor. In all, he was exposed to fumes about 15 minutes. This watchman had just completed dinner 15 minutes before starting work. He vomited his dinner and was dizzy; he also had some double vision; after vomiting, retching continued; his next two meals produced nausea and vomiting, but on the third day the symptoms passed.

4. An operator was dispensing about 80 cans of methyl bromide from an improvised container of approximately 2 liters in the crew's quarters on board ship, destroying bed bugs (*Cimex*). Considerable CH_3Br spilled on right hand which was protected by rubber glove. Chemical permeated the rubber and caused burning sensation. He removed the glove. In five hours, small water blisters appeared, which later coalesced and eventually broke down, reducing the entire hand to raw flesh. The operator was under the care of a physician, and it was 30 days before new skin developed and the bandage could be removed. The hand still is stiff, probably through lack of muscular activity for the long period when under bandage.

5. Workers where methyl bromide is manufactured had their hands exposed while loading tanks, resulting in dermatitis and small water blisters. Some of the blisters were reduced by application of bismuth subnitrate.

6. An operator experimenting in the destruction of termites under a large school house, over 300 feet long by 75 feet wide, with a clearance space about 18 inches, injected 10 cc. CH_3Br into 160 openings where covered runways entered the ground. He worked five consecutive days, and was forced to crawl on his stomach and drag an improvised applicator. Methyl bromide was injected within two feet of his face. Though the presence of methyl bromide was noticeable, no deleterious after effects were noted, except nasal irritation and slight headache.

7. The last case coming to our attention represents the first fatality that has occurred in California from methyl bromide. More than usual interest surrounds this case. The operator graduated from a prominent Western university in chemistry and had spent the past ten years on ship, mill and other structural fumigation work, being fully familiar with the majority of gaseous insecticides. He had worked practically exclusively with methyl bromide for a period of three or more months. I estimate that he had handled three or four tons of the material.

This man was fumigating a warehouse with a capacity of approximately 300,000 cubic feet of space, about 50 per cent filled with sacked rice. The building was of corrugated iron roof and sides and was not particularly tight. With him was an assistant. In the operations, the assistant tossed the cans to the operator, who was working and climbing about on the stacks of grain. The methyl bromide was dispensed from pound containers, which were opened singly, being punctured by hand with but slight modification from the way beer cans are opened. In all, 147 one-pound cans were opened and their

contents scattered in the house. One hour and fifteen minutes were required to dispense the fumigant. The operator was thus exposed to an increasing concentration of the vapors of methyl bromide for approximately the entire period. In addition, he probably exerted himself physically, promoting heavy breathing.

Both men wore gas masks of the type, M.S.A., Comfo Respirator, with small cartridges on either side, which are neither intended for high concentrations nor for prolonged exposures. The protection given by these masks was therefore very small.

On completion of the work at about 7:30 p.m., the men started for home, a distance of 140 miles. Within fifteen minutes of leaving the seat of operations, both men complained of a burning sensation around the eyes and in the nasal cavity. One and one-half hours later they were both sick and violently nauseated, one vomiting much more profusely than the other. During the drive home, both were affected by double vision, the operator to a greater degree than the assistant. They arrived home about midnight. The operator had chills and went to bed immediately. A physician was called. One hour and a half later the patient was taken with convulsions. The director of research of the concern manufacturing the methyl bromide was called. The physician administered sedatives to quiet the patient so that he could be removed to a hospital. The convulsions persisted throughout the night. The following morning, the medical official representing the state compensation insurance fund took charge of the case. The toxicologists of Stanford University and the professor of pharmacology of the University of California were brought into the case.

On the evening of the second day, the patient showed signs of recovery, with a temperature drop from 104 to 101 degrees, and convulsions only at rare intervals; he had regained partial consciousness and recognized persons around him. Medical attendants reported definite improvement and a 50-50 chance of recovery. On the third morning the patient took a turn for the worse, and the convulsions increased. At 11:15 p.m. of the fourth day, he passed away.

The assistant went to the hospital in a highly nervous condition, with headache and double vision, but had no convulsions. He remained there until discharged three days later by the attending physician. He was under a highly emotional strain, having heard of the effects on his co-worker, and was seemingly subject to considerable autosuggestion. Since that date, he has admitted some intermittent bronchial irritation. He has been X-rayed, and the physician has reported catarrhal spots in the bronchial region. The only other symptom is a slight pain in one leg between the knee and the thigh, which may or may not be traceable to the gas.

There is no question that the operator was exposed to increasingly high concentrations of methyl bromide for at least one hour and fifteen minutes without an adequate gas mask. Physical exertion of opening and dispensing the contents of 147 cans and climbing from pile to pile undoubtedly induced heavy breathing, thereby accelerating contact with the gas.

EXPLANATION OF TOXICITY.—The injuries caused by methyl bromide are apparently due to the rapid hydrolysis of the material in the presence of moisture under formation of hydrobromic acid, methanol and formaldehyde.

The following is quoted from a letter from Chauncey D. Leake, Professor of Pharmacology of the University of California:

"The general opinion of toxicologists is that the toxicity of methyl bromide is due to the formation and action of hydrobromic acid and methyl alcohol. Comments on the toxicity of methyl bromide appear in standard texts on toxicology. Most of the essential quantitative information regarding the effects of specific concentrations has been studied and the pathology has been reported upon. One per cent concentrations produce lacrimation, nose and lung irritation, weakness and unsteadiness in about 25 minutes with vomiting, and end with convulsive respirations, lung edema and death in about an hour. Lower concentrations will produce these same symptoms if inhaled for longer periods with the results proportionately prolonged. The man who died in Albany showed the classic picture of methyl bromide poisoning as described in R. W. Webster's *Legal Medicine and Toxicology*, Philadelphia, 1930."

CONCLUSIONS.—The vapors of methyl bromide are fatally toxic to member spe-

cies of a large group of insects and other forms of animal life; many forms of plant life, either in active or dormant stage, can accommodate themselves to its vapors for periods that are completely lethal to the parasites they support. If these considerations alone are to be met, its position is assured as a fumigant in the treatment of living as well as inert material.

The stability of its vapors under such physical conditions as moisture, temperature and pressure adds materially to the list of products that may be successfully treated. Its non-inflammability at all concentrations in which it might be used as a fumigant permits its use under conditions where this property is a dominant factor.

Lack of distinctive odor at doses that are toxic to the higher forms of animal life, makes its action more or less insidious, particularly where exposure is protracted, creating a natural presumption that in the hands of a person unfamiliar with its properties its use may expose the operator to considerable risk.

It may be taken for granted that this lack of distinctive odor can and will be compensated for by the addition of some warning compound, such as a lachrymator, that will act as a repellent to individuals in the danger area.

The mechanics of equipment for dispensing methyl bromide present no undue problem, and in most cases are either solved or in the way of solution.

In all fairness to this compound, it should be stated that publicity given methyl bromide, both before and in connection with the recent and only fatality, has resulted in the widespread dissemination of much information that is either erroneous or misleading.

Those considering its use will do well to make a comparison of its properties with those of other fumigants now offered for the control of insects and other animal pests. It is the writer's opinion that its virtues vastly transcend its shortcomings. —1-7-38.

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Laboratory Studies of Methyl Bromide as an Insect Fumigant[1]

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While methyl bromide is the most recent addition to the list of insect fumigants, it has been shown already to deserve a place of importance. The earliest report of its use for this purpose was made by Le Goupil (1932). Studying the toxicity of fumigants mixed with methyl bromide to overcome their inflammability, he found the latter was even more toxic than the compounds with which it was mixed. Vayssière (1934), de Francolini (1935a, b) and Lepigre (1936) have had

[1] Paper No. 1567, Scientific Journal Series of the Minnesota Agricultural Experiment Station.

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[3] Early publication of this paper has been secured by payment of the printing charge.

experience with the use of methyl bromide, particularly under vacuum conditions, at inspection stations in France, Morocco and Algeria, and regard it as a promising fumigant for a variety of purposes.

Methyl bromide, mixed with carbon dioxide, appeared recently as a commercial fumigant in the United States, although the results of neither laboratory or field tests were published prior to its marketing. Because of the attention thus drawn to the compound, methyl bromide was included in a study of the relative toxicity of the fumigants in commercial use (Shepard, Lindgren & Thomas, 1937). At the same time Mackie (1937) carried on numerous practical tests, involving particularly the effect of methyl bromide on living plants and fresh plant products. Lindgren (1936, 1937) reported that the commercial methyl bromide—carbon dioxide mixture penetrates readily bundles of burlap sacks, killing codling moth larvae buried therein.

PROPERTIES.—Methyl bromide (CH_3Br) boils at 4.0° to 4.5° C. (39° to 41° F.), considerably lower than any other insect fumigant. It is a relatively heavy liquid, having a density of 1.732 at 0° C.; its vapor density is 3.29. It is appreciably, although not highly, soluble in water under ordinary conditions, Lepigre (1936) reporting that a liter of water at 18° C. will dissolve 6 to 10 grams. The writers were unable to use mineral oil as a confining liquid in their burette for measuring methyl bromide because of the high solubility of the gas in the oil but used water for this purpose without much difficulty from the gradual absorption of gas by the water, although absorption was quite apparent. The methyl bromide used was guaranteed to be 99.5 per cent pure or better.

TOXICITY TO INSECTS.—The determination of the toxicity of methyl bromide under various conditions at atmospheric pressure was made as described by Shepard *et al.* (1937) and previous authors. It was found convenient to use one-way capillary stopcocks in one-hole rubber stoppers inserted in six-liter Erlenmeyer fumigation flasks, allowing the gaseous fumigant to be sucked from a gas burette into the partially evacuated flask.

Fumigants vary in their anesthetic action upon insects; hence in the degree of recovery in groups of insects which are apparently dead at the end of exposure. In order to eliminate this difficulty as much as possible it has been customary to determine the mortality in each lot at the end of 40 to 48 hours after exposure, and to count as dead only those insects which no longer exhibit movement to the unaided eye. As some fumigants are slower in their toxic action than others, it is important to determine the recovery or death of treated insects after periods longer than 48 hours.

Adults of *Tribolium confusum* Duv. were exposed to different fumigants at concentrations to kill various percentages. Although a few crippled individuals in most of the lots did not succumb up to about 10 days after exposure, most of the mortality took place in the first two days in the case of methyl bromide, ethylene oxide and chloropicrin. Ethylene dichloride appears somewhat erratic, with low concentrations acting slowly but rather steadily over approximately eight days. Carbon disulfide shows very striking results, all the insects exposed to it being anesthetized upon their removal from the fumigation jars; in one lot at least 99 per cent were active at the end of 24 hours, but 69 per cent were dead in 3 days, 93 per cent in 6 days and 100 per cent in 9 days. Striking results at the opposite extreme were obtained with hydrocyanic acid in which case the final result is approximated at the time of removal of the insects from the gas; no change occurs after the first day. Granary weevils sometimes recover from hydrocyanic acid during the first day after exposure.

It has been reported by Shepard *et al.* (1937) that methyl bromide lies between chloropicrin and ethylene oxide in toxicity to *Tribolium confusum*. Somewhat more methyl bromide is required to kill these insects than is required of hydrocyanic acid. There is little difference, however, in the toxicity of these four fumigants to *Sitophilus granarius* (L.). It is quite clear then that methyl bromide compares favorably with the more important fumigants in toxicity to these well known test insects.

The relative resistance of a few species of common stored product pests to methyl bromide is given in table 1. Incomplete data indicate that *Oryzaephilus surina-*

mensis (L.) (saw-toothed grain beetle) and a *Laemophloeus* species (flat grain beetle) are less resistant to this fumigant than is the granary weevil.

The eggs of *T. confusum* are considerably less resistant to methyl bromide than are the adults, the median lethal concentration at 25° C. and a five-hour exposure being 5.5 to 5.9 mg. per liter.

Table 1.—Relative toxicity of methyl bromide to the adults of different species of insects at 25° C. exposed for 5 hours.

SPECIES	COMMON NAME	CONCENTRATION TO KILL 50 PER CENT
Tribolium confusum Duv.	Confused flour beetle	10.2 mg. liter
Sitophilus granarius (L.)	Granary weevil	5.5 mg. liter
Sitophilus oryzae (L.)	Rice weevil	4.0
Acanthoscelides obtectus (Say)	Bean weevil	6.1 mg. liter

ABSORPTION.—The degree to which different fumigants are absorbed by fine-ground whole wheat flour was determined by hanging test cages of insects above two-inch layers of flour in the six-liter fumigation flasks. In order to kill 50 per cent of the insects in the presence of the flour it is necessary to use enough fumigant to satisfy the absorptive capacity of the flour and yet maintain the proper concentration in the atmosphere surrounding the insects. No correction has been attempted for the space occupied by the flour, amounting to about two liters, nor for the time required to reach equilibrium. Further work should be done to determine the rate of absorption. This factor appears likely to be particularly important in differentiating the action of hydrocyanic acid from that of other fumigants such as methyl bromide.

As shown in table 2, flour absorbs rather large quantities of any fumigant, but the extent of absorption depends upon the properties of the particular chemical used. Closely related compounds having similar properties are absorbed to about the same extent. The absorption ratio is obviously related to the vapor pressure as indicated roughly by the boiling points, although the series shows considerable irregularity in this respect. The absorption ratio of ethylene oxide, a compound with unexpected behavior in other respects, is distinctly out of line with the other ratios as arranged by the boiling points. However, ethylene oxide is not absorbed nearly so much as is chloropicrin, a result in accord with the findings of Cotton (1930).

A short additional series of tests made with carbon disulfide, indicates the ratio given for that fumigant may be somewhat low. Whereas an absorption ratio of 8 for ethylene dichloride was indicated by Shepard *et al.* (1937), the figure for that compound given in table 2 is the result of much more extensive tests. Water solubility of a fumigant must also have considerable influence on the absorption ratio, but this factor has received little attention.

Table 2.—Absorption ratios for various fumigants in the presence of flour at 25° C. and atmospheric pressure, compared with the boiling points of the fumigants.

FUMIGANT	MEDIAL LETHAL CONCENTRATION (No Absorbent)	MEDIAN LETHAL CONCENTRATION (Flour)	ABSORPTION RATIO	BOILING POINT
Methyl bromide	10.2 mg./l.	21 mg./l.	2	4.5° C.
Ethylene oxide	15.5	96	6	11
Hydrocyanic acid	—	—	2	26
Methyl formate	18	78	4	32
Carbon disulfide	64	147	2.5	46
Ethyl formate	22	90	4	54
Ethylene dichloride	46	240	5	84
Propylene dichloride	45	235	5	97
Chloropicrin	3.9	35.5	9	112
Tetrachlorethylene	54	440	8	120
Methyl thiocyanate	1.4	14	10	130

In view of the fact that the median lethal concentrations without flour, tabulated with the corresponding tests with flour, do not agree exactly with the determinations previously published for the same conditions, the absorption ratios are given in most cases only to the nearest whole number. The previously published figures are based for the most part on many more tests involving the work of several years. It should be pointed out that the absorption ratios given are purely relative and cannot be used directly in the calculation of practical dosages where the ratios of flour volume to flour surface to room volume are different from those in the standard laboratory technique. Different lots of the same grade of flour might vary markedly in the adsorptive capacity of the particles but the use of different lots in these experiments is thought not to introduce errors not cared for in the treatment of the data.

Several tests were made in which four liters of flour were placed in a six-liter flask, a cage of adult *T. confusum* hung over the flour and another buried four inches in the flour. The flour had a depth of five inches and an exposed surface diameter of six inches. Each of seven flasks so arranged was treated with methyl bromide at the rate of 32 mg. per liter (2 pounds per 1,000 cubic feet) for the entire volume including the space occupied by the flour. This dose in a flask without flour would be three times enough to kill 50 per cent of the insects. The average kill at a depth of four inches in the flour was 59.8 per cent. No comparable figures are available for other fumigants; so no conclusions can be made regarding relative penetration except on the basis of table 2.

VACUUM FUMIGATION.—Reports of laboratory experience in the determination of fumigant toxicity at different levels of reduced pressure appear to be entirely lacking. The writers have used equipment for this type of work similar to that employed by Jones (1933) who measured various quantities of vaporized fumigants in terms of pressure differences registered on a mercury manometer, although his flasks were brought to atmospheric pressure for the period of exposure.

For work at reduced pressures it is necessary to substitute five-liter balloon flasks (volume 5.43 liters) for the Erlenmeyer style used at normal pressures. The manometer was attached to a pint cylinder of methyl bromide or other compressed fumigant on the one hand and to a vacuum pump on the other. The original vacuum drawn in each test was enough to allow the suction of the required dose of gas into a fumigation flask and still have the vacuum level desired for the period of exposure. By using a 130 ml. accumulator bulb between the manometer and the fumigation flask the pressure exerted by a given volume of gas was increased so that it could be measured readily in centimeters of mercury rather than in millimeters as is the case without this arrangement. Ninety minutes, the minimum exposure in common use in practical vacuum fumigation, was the exposure time in these vacuum experiments, instead of the five-hour period used in laboratory work at atmospheric pressure.

Jones calibrated his apparatus by breaking a number of weighed ampules of each fumigant in the partially evacuated apparatus and noting the resultant pressure differences. In the present study, however, the relation of dosage to the pressure differences was calculated from the fundamental gas law, $PV = RnT$. Results on this basis checked rather closely with results for the same gases supplied from a gas burette. A small correction factor (1.05) is in use at present in order to secure better agreement of the values based on the gas law with those obtained volumetrically in using the gas burette.

In these experiments only the lowest pressure (30 mm. mercury = a 28-inch vacuum) affected adult *Tribolium confusum*, killing from 16 to 22 per cent in controls held under these conditions for 90 minutes. However, less than 1 per cent mortality occurred when a small amount of water was exposed in each flask, indicating that water loss is considerable, and often fatal, in insects exposed to a dry vacuum. In fact the moisture from fresh wheat flour is sufficient to protect the insects from dessication. On the other hand when moisture is present in the fumigation flask at 30 mm. pressure the median lethal concentration is lower, i.e., 10 mg. per liter, than when dry vacuum is used, i.e., 14 mg. per liter.

Absorptive materials were introduced into the balloon flasks to a depth of 2.5

inches in the center, the exposed upper surface of the material being 7.25 inches in diameter. The volume of this quantity of material is approximately 900 ml., the weight of flour being 600 grams, of wheat 850 grams and of loose, dry raisins 650 grams. See table 3.

An approximate correction for the space occupied by the absorptive material was made by reducing the values for the empty flask to allow for the volume (900 ml.) occupied by the absorptive, the ratio of the two series of values being as 5.43 liters to 4.53 liters. Very little methyl bromide was absorbed by the raisins, slightly more by the wheat. Throughout the pressure range the flour absorption ratio for methyl bromide remains at approximately 2.

It should be noted that reducing the exposure from 5 hours to 90 minutes increases the median lethal concentration for *T. confusum* adults from 11 to 32 mg. per liter. In addition the presence of flour increases the fumigant requirement but this increase is not greater under vacuum than at ordinary pressures. On the other hand increasing the vacuum decreases the fumigant dosage necessary to obtain a given kill. The reduced time of exposure ordinarily allowed for vacuum fumigations is the most important factor then, in making high concentrations of fumigant necessary in this type of work.

TEMPERATURE.—In table 4 are given the median lethal concentrations of methyl bromide for *Tribolium confusum* and *Sitophilus granarius* at different temperatures, no absorptive material being used. A little work has been done relative to the effect of temperature on absorption at atmospheric pressure, chiefly by Strand (1927). The effect of temperature on the absorption of a fumigant under reduced pressures has not been studied yet in the laboratory.

Judging from the difference between the median lethal concentrations at 35° and 15° C., one may assume the toxicity of methyl bromide to be affected about as much by temperatures of this range as that of carbon disulfide and considerably less than that of chloropicrin.

MOISTURE.—Adult *Tribolium confusum* exposed to methyl bromide for 5 hours at atmospheric pressure, 25° C. and a relative humidity of 80 to 90 per cent require a median lethal concentration of 8.5 mg. per liter; if at a relative humidity of 10 to 20 per cent the medial lethal concentration is increased to 10.5 mg. per liter.

Previous experience with the effect of moisture upon the toxicity of fumigants (Lindgren & Shepard 1932) leads one to expect greater influence upon the toxicity to the egg stage than upon that to the adult. However, moisture affects the toxicity of methyl bromide to the egg stage so little that the difference is of doubtful significance.

EFFECT ON GERMINATION OF SEEDS.—A fumigant to be of all-around practical value should not affect seriously the germination of seeds. In table 5 are given the

Table 3.—Toxicity of methyl bromide at various pressures in the presence of different absorptive materials; median lethal concentrations in milligrams per liter for *Tribolium confusum* at 25° C. and 90 minutes exposure.

	ATMOSPHERIC PRESSURE	480 MM. PRESSURE	240 MM. PRESSURE	120 MM. PRESSURE	30 MM. PRESSURE
Empty Flask	32.5	28.2	21.0	20.3	14.0
Empty Flask (corrected)	26.5	23.0	17.1	16.6	11.4
Raisins	28.1	—	16.8	—	12.6
Wheat	30.4	26.3	17.2	—	14.2
Flour	50.0	41.9	34.0	32.9	26.0

Table 4.—Relation of the toxicity of methyl bromide to temperature, median lethal concentrations for an exposure of 5 hours at atmospheric pressure.

TEMPERATURE		*Tribolium confusum*	*Sitophilus granarius*
35° C.	95° F.	6.7 Mg./liter	3.8 Mg./liter
30	86	7.9	4.7
25	77	10.2	5.5
20	68	14.2	6.5
15	59	18.0	7.5
10	50	—	14.5
5	41	36.0	—
0	32	—	70.0

results of tests with methyl bromide in this respect. There appears to be little chance of injury to the germination of dry seeds although de Francolini (1935a) made a brief series of tests indicating slight injury in some cases when seeds were exposed to a concentration of 55 mg. per liter for 24 hours.

The relation of absorption to the boiling point of the fumigant is discussed. Absorption ratios are given for most of the common fumigants.

The influence of various reduced pressures upon the toxicity of methyl bromide and their relation to the presence of absorptive materials, such as raisins, wheat and flour, were investigated.

The toxicity of methyl bromide appears to be affected by temperature about as much as carbon disulfide is, and considerably less so than is chloropicrin.

In general, methyl bromide is definitely more effective when it is in the presence of moisture.

Seed germination is not affected noticeably by methyl bromide treatment. Corn, wheat, oats, barley, beans and field peas were tested.—1-7-38.

Table 5.—Germination of seeds fumigated with methyl bromide; exposure 5 hours.

VARIETY	CHECK	2 lbs. per 1,000 cu.ft. (32 mg./l.)	5 lbs. per 1,000 cu.ft. (80 mg./l.)	10 lbs. per 1,000 cu.ft. (160 mg./l.)
Corn, Minhybrid 301	99	99	97	99
Oats, Anthony	91	94	94	92
Barley, Wisconsin 38	99	98	95	98
Wheat	68	67	67	71
Beans, Black Turtle Soup	98	98	—	98
Peas, Marrowfat Field	85	90	—	83

SUMMARY.—Methyl bromide is a promising new fumigant with a lower boiling point (4.5° C.) than other fumigants. It was used as a fire extinguishing chemical previous to the discovery of its value as an insecticide.

In toxicity to insects methyl bromide compares favorably with hydrocyanic acid, chloropicrin and ethylene oxide. The eggs of *Tribolium confusum* are considerably less resistant to this compound than are the adults.

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Experiments with Paris Green and Calcium Arsenite as Larvicides for Culicine Mosquitoes

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Paris green (copper acetoarsenite) is highly toxic as a stomach poison to mosquito larvae, much more so than some of the other arsenical insecticides such as lead arsenate and calcium arsenate, and is now used extensively in the control of anopheline mosquitoes. The material is effective in very small quantities and, since *Anopheles* larvae feed at the surface of the water, it can be applied economically as a dust in a mixture with an inert diluent.

Attempts have been made to produce a suspensible form of Paris green, or to find some other method for employing it against subsurface-feeding larvae. Griffitts (1927) found that larvae of the salt-marsh species *Aedes taeniorhynchus* (Wied.) and *A. sollicitans* (Walk.) could be killed by hand broadcasting a mixture of Paris green and moist sand over the breeding places. His observations indicated that the poison was ingested by the larvae at the bottom of the pools, where it was carried by the damp sand. The weight of this carrier, however, precluded its use in large scale work.

Field Tests.—In a small field test conducted by the senior author in 1935, a high percentage of kill with larvae of *Aedes taeniorhynchus* was obtained by spraying the breeding place with a mixture of Paris green and water; a small pressure sprayer was used. During the following year, when a request was received for advice from the Anti-Mosquito District of Pinellas County, Florida, the suggestion was made that an ordinary sprinkling can be tried for spraying the breeding places with wet Paris green. Reports of the first trials by Mr. Strickland, Superintendent of the Anti-Mosquito District, having indicated that the method was a promising one for killing *Aedes* larvae, and more economical than oiling, arrangements were made for the junior author to conduct a series of field tests in Pinellas County.

Prolific breeding of *Aedes taeniorhynchus*, with some *Psorophora columbiae* (Dyar and Knab) and *Culex* sp., was found on grassy flats and swales that had been flooded recently with rain water. Small measured areas were selected in a variety of places, and the wet Paris green was applied with a sprinkling can at rates of from 1 to 10 pounds to the acre. The water in most of these places varied in depth from a few inches to about 12 inches, and the rankness of the vegetation, principally *Distichlis*, also varied considerably. A high larval mortality among the *Aedes* and *Psorophora* occurred in all the tests, even with the lowest quantities used. The ease of application and the very favorable results indicate that this method may have a rather wide field of usefulness against the salt-marsh species, as well as others of these two genera whose larvae have the habit of feeding commonly at the bottom of the pool. In this connection, however, it may be mentioned that previous attempts by the junior author to poison the larvae of *Mansonia perturbans* (Walk.) by this method were unsuccessful, probably because these larvae, although living continuously at the bottom, are usually buried in a layer of mucky material.

Three-gallon or four-gallon sprinkling cans are convenient sizes to use for spraying and, in operation, are swung back and forth in front of the worker, covering a swath 10 to 12 feet wide. Two gallons of water were found to cover about 1,250 square feet and should, therefore, contain about 1 ounce of Paris green for an application at the rate of 2 pounds to the acre. The water may be dipped from the breeding place as needed but, if full of trash, should be strained to prevent clogging of the nozzle. The cans are easier to handle without spilling the water if they are filled not more than about three-fourths full.

While the tests were under way, observations were made on the treatment of a *taeniorhynchus* breeding area of about 20 acres on Egmont Key. The location was a low, grassy flat covered with water to a maximum depth of about 12 inches. A crew of three men employed by the County Anti-Mosquito District treated the area in approximately 2 hours, using three-gallon sprinkling cans and distributing a total of about 40 pounds of Paris

green. The foreman of the crew carried the supply of Paris green and furnished measured quantities to the men as needed. A larval mortality rate of 70 to 80 per cent was estimated at the end of two hours. Although a later examination was not made, because of the inaccessibility of the Key, the high early kill indicated that the mortality would be nearly complete.

AUTOGIRO EXPERIMENTS.—During the early spring of 1937, an opportunity occurred to conduct two experiments on the application of the wet Paris green by means of an autogiro equipped for spraying liquids. In these tests the plane was flown over two lines of dishes containing fourth instar larvae of *Culex quinquefasciatus* Say, the lines being placed at right angles to the direction of flight, 500 feet apart.

In the first test 4 pounds of Paris green were mixed in 25 gallons of water, and the distributor in the plane was set for a delivery rate of about 12 gallons per 1,100 feet of flight (12 gallons per acre for a swath width of 40 feet). Each line of larval containers consisted of seven dishes spaced at 10-foot intervals. Four of the dishes were enamelware pans, 11 inches in diameter, containing 20 larvae each; these were alternated with three 1-liter beakers containing 10 larvae each. The plane was flown at a speed of about 45 miles an hour and at an altitude of 8 to 10 feet above the ground.

Larval mortality in the 14 dishes was as follows: 56 per cent at 5 hours, 90 per cent at 24 hours, and 98.2 per cent at 48 hours, one larva each in four pans surviving out of a total of 220. The results showed that the spray had been evenly distributed and had undoubtedly covered a swath of more than the 60 feet over which the pans were spread. The rate of application, therefore, was less than $1\frac{1}{2}$ pounds of Paris green per acre. The slow rate of kill, in comparison with results of laboratory tests, indicated that the dishes received the equivalent of only a very small fraction of this amount. Since the spray was blown in a nearly horizontal direction, or at least at a very acute angle, it is probable that the water in the container was protected by the sides of the dishes and did not receive as much of the spray as did equal areas on the ground.

In the second test two days later, nine pans were spread over a distance of 90 feet in each line, the first two pans from the center being spaced at 15 feet, the others at 10 feet. The dishes contained 20 larvae each, and the spray consisted of 8 pounds of Paris green in 25 gallons of water. Ten of the pans (five in each line closest to the line of flight) showed 96 per cent mortality in 24 hours. Eight of the 10 pans had a total of only six larvae alive at 4 hours and one alive at 6 and 24 hours. The eight outer pans (four in each line) had a 24-hour mortality of 61 per cent. The effective swath width in this test was at least 50 feet.

In neither test did mortality occur among check larvae.

The principal interest in the results of these tests was the demonstration that the Paris green would remain moist enough to sink upon striking the water after being exposed to the strong air blast, and that the distribution was fairly even over the central portion of the swath. Tests in natural breeding places will be required to determine the practical application of the operation.

CALCIUM ARSENITE.—Two samples of calcium arsenite were furnished us by one of the commercial chemical companies and have been compared with Paris green in laboratory tests with *Culex* larvae. One of these samples was said to contain approximately 2.5 per cent water-soluble arsenic and the other, 8 per cent. On the basis of killing time, the latter showed the higher toxicity and was intermediate in this respect between the two best samples of Paris green. The other sample showed about the same killing time as the third sample of Paris green. While the calcium arsenite has not been prepared commercially, we are advised that it can be manufactured at a much lower cost than Paris green. If so, the results of these preliminary tests indicate that it may prove to be a satisfactory substitute for the more expensive material.*—9-17-37.

* Since preparing this report, we have noticed a review of a Russian article by Ul'yanishchev and Rifling (abstracted in Rev. App. Ent., Ser. B, 25: 68. March, 1937) in which it is stated that calcium arsenite had proved effective in both laboratory and field tests against anopheline larvae. In these tests it was used in a 1–4 mixture with "oleogumbrin," said to be one of the waste products of oil refining.

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The Effect of Insecticides on a Beneficial Coccinellid, *Hippodamia convergens* Guer.

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Comparatively little information exists in the entomological literature relative to the effect of insecticides on beneficial insects. Clausen (1936) has reviewed the work on this subject and shows that a number of general observations have been recorded, but no extensive studies have been conducted on the effect of a series of common insecticides on any beneficial insect.

It is hoped that this contribution will awaken interest among entomologists in the question, "How and to what extent do insecticides affect the natural enemies of insect pests?" The authors are of the opinion that, sometime in the future, field results with insecticides on economic pests will include the effect of the insecticides employed upon the natural enemies of the pest the investigator is attempting to control. This will be particularly true among pests where it is apparent that biological control plays an important role in checking devastations.

Several years ago the junior author proposed the problem discussed in this paper. The senior author accepted the problem for his graduate research work. At the outset and throughout the investigation, the senior author developed some interesting and new methods and equipment to keep the beetles alive, to produce eggs, to rear larvae, etc. It is hoped that the senior author will be able to publish his results on this matter in the near future. The junior author prepared the final draft of this paper for publication in order that the insecticide results might appear at an early date.

The coccinellid selected for this study was *Hippodamia convergens* Guer. This species is very satisfactory for several reasons. It is an important species and found in most parts of the United States and elsewhere. It feeds readily on many species of aphids and on frozen aphids which makes it easy to rear. Also it may be purchased in large quantities from commercial insectaries.*

General Methods.—All the insecticide tests reported in this paper on adults, eggs and larvae were conducted in a greenhouse or in basement laboratories. Temperature and humidity records were taken during the period of each experiment. An air pressure gun was used for spraying, at 12 pounds pressure for adults (in screen cages) and at 6 pounds pressure for eggs and larvae. All spraying was done in the laboratory with clean equipment, and each spray mixture was made up carefully in distilled water before it was applied. All figures on the per cent of kill are based on the well known formula $\frac{x-y}{x} \times 100$, where x = the per cent living in the checks and y = the per cent surviving the treatments. In the determination of adult mortality, the beetles were classified as living, moribund and dead. A living beetle was one that could move forward no matter how feeble it might be. A moribund beetle was alive and could move its appendages yet was unable to crawl. In determining kill, moribund beetles were grouped with individuals that showed no signs of life. Many of the feeble beetles classed as living died after three days. This was particularly true when derris was used.

Methods with Adults.—The adults used in the tests were taken from two separate shipments (March, May, 1936) from California. Upon arrival, via air express, the adults were placed in a refrigerator at 2° C., watered periodically and removed when needed.

Three types of cages were used for the adults. The plant cage was the one used most extensively, fig. 1. It was made of 12-mesh galvanized screen and resembled an inverted cone with a flat top. The measurements were $8\frac{1}{2}$ inches high, $3\frac{3}{4}$ inches across the bottom opening and $6\frac{1}{2}$ inches across the closed flat top. The screen door was made of the same material as the cage and covered a small opening on one side. The door swung on three hinges of soft wire, was oversized and was kept closed by a short, straight piece of spring steel wire with the two ends forced by bowing through the screen mesh. The cage was placed over aphid-

* A. W. Morrill, California Insectaries, Inc., Glendale, Calif.

infested nasturtium plants or portions of other plants. A small aluminum strip tag was wired to each cage. Before each test the cages were washed thoroughly and paraffined. To paraffin a cage it was rolled

FIG. 1.—Plant and adult cage.

in melted, smoking paraffin until the sides were covered completely. The flat top also was dipped into the paraffin. It was then lifted out of the paraffin quickly and hit sharply with the left hand to free the meshes of excess paraffin. The lower margin of the cage was pushed into the moist soil in a 4-inch flower pot. The space between the edge of the cage and the sides of the pot was filled with dirt and packed tightly.

A second type of cage, fig. 2, for adults was a flat wire screen container made of 12-mesh galvanized wire screen. It was 4 inches×4 inches×$\frac{3}{4}$ inch deep with a 2×2 inch square opening on the upper side. The door swung on two soft wire hinges and was closed by a short piece of spring steel wire. The whole cage was washed and paraffined before each spray test.

The third type of cage for adults was one-half of a Petri dish covered with 12-mesh wire screen. The beetles, 50 in each cage, were sprayed through the screen sides of the cage. After spraying, the screen side of the cage was placed downwards.

Bean aphis, *Aphis rumicis* L., on nasturtium plants proved to be satisfactory as food for sprayed coccinellids. Under high temperatures and a continuously moist soil, satisfactory plants and an ample aphid population can be produced in 13 to 15 days. At lower temperatures or with less soil moisture, plant production was slower. The first nasturtium sprouts appeared above ground three days after the seeds were planted. Six days after planting, when the sprouts averaged one-half inch in height, the plants were infested with aphids. Seven to nine days later, the plants were just the right size to use in the plant cages and had become heavily infested with aphids.

In planting seeds, pretreated with "Cupricide" dust, an aluminum ring, $2\frac{3}{4}$ inches in diameter and made from an aluminum strip, $\frac{1}{2}$ inch in width, was placed on the surface of the soil in the center of a 4-inch flower pot. The seeds were placed inside the ring and then covered with soil. The ring was removed and soil was packed tightly over the seeds in the pot.

Five methods were used in conducting tests with adults. The majority of the tests were with method 1. Under method 1, 25 adults were placed in a wire screen plant cage, fig. 1, in which were nasturtium plants heavily infested with bean aphids. In the early tests, the beetles were permitted to feed for 24 hours before they were sprayed. This was found to be un-

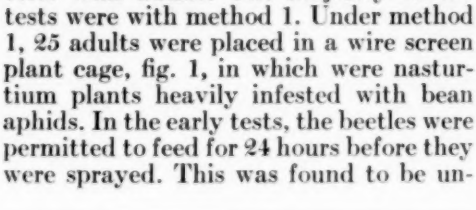

FIG. 2.—Wire screen cage for adults.

necessary and the practice was dropped. With the spray gun held in the right hand 12 inches away from the screen cage, the spray was directed on to the beetles and the plants within the cage, while the left hand slowly revolved the pot over

which was the cage. Each sprayed cage was replicated four times for each test of a given insecticide. After a cage was sprayed it was wiped dry with soft cheesecloth and set aside in the greenhouse. If the temperature of the greenhouse was too high, the cage was placed in the laboratory. On the third day after spraying, the mortality counts were made and the tests discontinued. The above method favored the insecticide because the adults were forced to remain on sprayed plants and aphids. To eliminate this difficulty method 2 was applied.

the adults were kept in these cages until the third day.

In method 4, the adults, 50 per cage, were sprayed in small screen cages, fig. 2; they were kept in these cages until the third day, when the results were recorded.

Method 5 is the same as method 2 except for predrinking; that is, the adults were sprayed with distilled water one or more times previous to the application of the spray. During the progress of the investigations, it was discovered that thirsty beetles reacted differently to a few

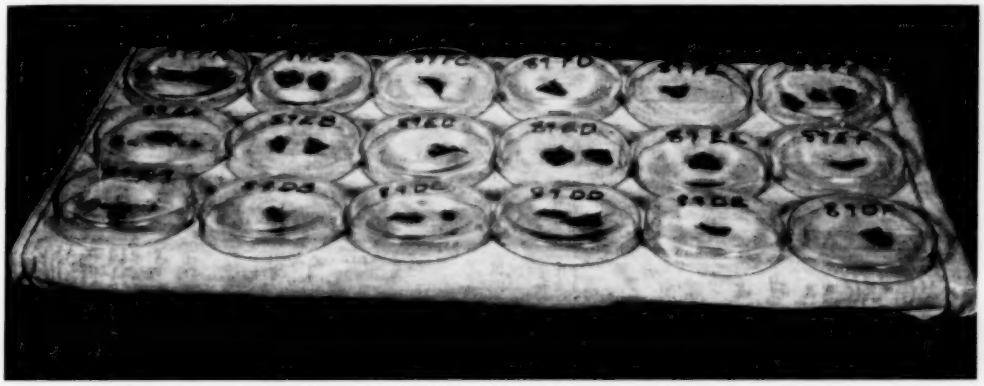

FIG. 3.—A gauze covered tray bearing sprayed eggs on foliage placed on glass slides below halves of Petri dishes.

In method 2, the adults were placed in small, flat wire screen containers, fig. 2, and sprayed. As soon as the spraying was complete the cage was jarred slightly over the back of one hand to remove the excess spray; also all visible spray was wiped off with a clean cheesecloth. The cage containing the sprayed adults was then allowed to stand for 15 minutes in front of an electric fan; within a few minutes the beetles and cage were dry. Then the 25 beetles from each replicate cage were removed from the wire screen cage by means of a suction collector and transferred to clean plant cages containing unsprayed aphid-infested nasturtiums. Mortality records were made on the third day. This method parallels conditions in the field where sprayed adults might migrate to unsprayed foliage and aphids.

In method 3, the adults, 50 per cage, were placed in Petri dishes covered with screening, and sprayed. The screen side of the dish was placed downwards and

of the insecticides than beetles that had been in contact with water previous to the application of the insecticide.

METHODS WITH EGGS.—All the eggs used in the ovicide tests were deposited by adults shipped from California. The eggs were deposited on smooth foliage of *Spiraea Vanhouttei* Zabel in oviposition chambers.* The original incubation chamber consisted of a cheesecloth covered embroidery hoop placed over a small half of a paraffined Petri dish containing water and covered with the top half of a petri dish. This method was later discarded for a tray system, fig. 3. A shallow metal pan 12 inches×25 inches×$\frac{3}{4}$ inch deep was filled with strips of cellucotton saturated with water. A removable eight mesh hardware cloth cover was placed over the top. This was covered with two layers of cheesecloth held in place by rubber bands at each end. The sprayed

* Oviposition and rearing methods will be discussed in a paper to be prepared for publication by the senior author.

egg clusters, always on foliage (usually Spiraea) were placed on small glass slides that rested on the cheesecloth over the moist chamber. Each cluster of 25 or more eggs in a given replicate was covered with one-half of a Petri dish. Each insecticide had six replicates and one tray held 18 replicates.

When the eggs were sprayed, a leaf bearing a cluster of normal, uninjured eggs was lifted from the container by a pair of forceps and held in the spray about two feet from the spray gun. Each cluster was thoroughly moistened with the spray. The excess spray was drained and absorbed from the leaf by a small piece of cellucotton. Then the leaf bearing the sprayed egg cluster was placed on a glass slide, 1×3 inches, on the cloth cover over the water tray and covered with one-half of a Petri dish.

As soon as hatching started among treated and check eggs, they were examined every two or three hours during the daytime and every six hours at night as long as hatching took place. Even though this precaution was taken, about 12 per cent of the eggs were injured by the newly hatched larvae. At a temperature of 76° F. and in the presence of high humidity, the first hatch occurred within 48 to 72 hours and nearly all had hatched in 72 to 96 hours. At 82° F. and in high humidity the first hatch occurred in 24 to 48 hours and was completed in 48 to 72 hours.

METHODS WITH LARVAE.—All larvae tested were reared first stage larvae. The tests were conducted at 77° to 84° F. The first instar larvae were from eggs deposited on spiraea foliage located under one-half of a Petri dish on cheesecloth stretched across embroidery hoops. The embroidery hoops were placed above dishes containing water. Frozen poplar gall aphids (Haug, 1936) were used as food in the insecticide tests.

The great activity of newly hatched larvae necessitated rapid work in making the spray tests. Fifteen larvae were transferred with a camel-hair brush to the bottom of a Petri dish covered with filter paper previously moistened with the insecticide to be tested. The free moisture on the paper slowed down the activity of the larvae while the spray was directed on to them. After spraying was complete, the 15 larvae were transferred quickly by a camel-hair brush to dry cheesecloth stretched over an embroidery hoop on which numerous frozen poplar gall aphids were located. The cloth of the embroidery hoop was placed over a dish of water and the larvae and aphids were covered with one-half of a petri dish. There were six replicates to each test. To resemble field conditions more nearly, the aphids in some of the tests were also sprayed with the respective insecticides. A few tests conducted indicated that this procedure made no difference in the results. Mortality counts were made the day following the day of spraying.

INSECTICIDE RESULTS.—About a dozen common insecticides were tested. They are discussed in alphabetical order. The effect of each insecticide on adults, eggs and larvae are presented under the respective insecticide.

Anabasine sulfate, 40 per cent, 1 part to 400 parts of water. This product was tested once on first instar larvae. The kill was 2 per cent.

Black Leaf 40, 55 per cent nicotine sulfate, 1 part to 800 parts of water plus Red A soap, 1 part to 100 parts of volume. *Black Leaf 40* on the adults under method 1 in eight experiments gave 12 to 47 per cent kill, averaging 26 per cent; under method 3 in four experiments it gave 2 to 8 per cent kill, averaging 5 per cent; under method 4 in two experiments it gave 20 to 23 per cent kill; and under method 5 in one experiment gave 6 per cent kill.

Greater variation occurred in the results with *Black Leaf 40* on adults than with any other insecticide. In some measure this may be the result of the fumigation effect of nicotine, particularly in method 1 in which the beetles were confined to sprayed foliage. In the methods where the beetles were not confined with the spray on foliage or elsewhere, the kill was consistently low.

Three experiments with *Black Leaf 40* were conducted on eggs and the results were 0.4 and 0 per cent kill. Four experiments with *Black Leaf 40* were conducted on first instar larvae and the results were 0, 0, 0 and 20 per cent kill, averaging 3 per cent.

Bordeaux mixture, formula 4–4–50. Bordeaux mixture on adults under method 1 in four experiments gave 2 to 25 per cent kill, averaging 15 per cent; under method 3 in one experiment it gave 13 per cent

kill; and under method 4 in two experiments it gave 45 to 83 per cent kill.

Five experiments with Bordeaux mixture were conducted on eggs and the results were 0, 0, 14, 7 and 0 per cent kill, averaging 5 per cent. No tests with Bordeaux mixture were conducted on larvae.

The results with Bordeaux mixture were variable. It is believed that the mortality of beetles was greatest among adults that did not have access to water. Further tests are needed to ascertain the effects of Bordeaux mixture on adults.

Calcium Arsenate, 1½ pounds to 50 gallons of water plus 4 pounds of hydrated lime. Calcium arsenate on adults under method 1 in four experiments gave 16 to 31 per cent kill, averaging 24 per cent and under method 4 in one experiment gave 100 per cent kill. One experiment with calcium arsenate on eggs and one on first instar larvae gave no kill.

Cryolite, a synthetic mixture of fluoaluminates, etc., chiefly sodium aluminum fluoride, 3 pounds to 50 gallons of water. Cryolite on the adults under method 1 in three experiments gave 7 to 23 per cent kill, averaging 14 per cent.

Five tests were conducted with cryolite on eggs and the kill was 13, 0, 11, 0 and 0 per cent, averaging 4 per cent.

Three experiments were conducted with cryolite on larvae, and the kill was 28, 9 and 18 per cent, averaging 19 per cent.

Derris, ground root suspension, rotenone analysis 5 per cent in 14 per cent ether extractive, 1½ pounds to 50 gallons of water. Derris on the adults under method 1 in six experiments gave 67 to 74 per cent kill, averaging 71 per cent; under method 2 in three experiments it gave 98 and 99 per cent kill; under method 3 in three experiments it gave 37 to 71 per cent kill, averaging 57 per cent; under method 4 in three experiments it gave 63 to 86 per cent kill, averaging 72 per cent; and under method 5 in two experiments gave 73 to 78 per cent kill.

The results with derris on adults were practically constant. Except for one test out of 17, which gave 37 per cent kill, the percentage of dead beetles ran high, in most cases about 70 per cent.

Derris was used in eight tests on eggs and produced 0, 3, 11, 25, 16, 19, 13 and 7 per cent kill, averaging 14 per cent. These percentages are based on actual hatching. They are not true figures of the mortality that resulted, because many of the newly hatched larvae died a short time after they left the empty egg shell.

Derris was used in three tests on first instar larvae, and the kill was 47, 43 and 48 per cent, averaging 46 per cent.

Dutox, active ingredient barium fluosilicate 72 per cent and sodium fluosilicate 8 per cent, 1½ pounds to 50 gallons of water. *Dutox* on adults under method 1 in three experiments gave 11 to 18 per cent kill, averaging 14 per cent; under method 4 in one experiment it gave 13 per cent kill. The results with *Dutox* were fairly constant.

Dutox was tried on eggs in two tests and produced no kill. It was also tried on first instar larvae in two experiments and gave 0 and 2 per cent kill.

Evergreen, pyrethrum extractive 6 per cent, 1 part to 400 parts of water. No tests were conducted on adults or eggs. *Evergreen* was tried in two experiments on first instar larvae and gave 13 and 3 per cent kill, averaging 8 per cent. *Evergreen* was tried in three tests on eggs and gave 0, 2 and 9 per cent kill, averaging 3 per cent.

Kalo, a natural cryolite, sodium aluminum fluoride not less than 90 per cent, 2 pounds to 50 gallons of water. *Kalo* on adults under method 1 in three experiments gave 0 to 8 per cent kill, averaging 4 per cent; under method 4 in one experiment it gave no kill.

Kalo on eggs in two tests produced no kill. When used on first instar larvae in three tests it gave 14, 21 and 6 per cent kill, averaging 14 per cent.

Lead Arsenate, powder, 1½ pounds to 50 gallons of water. Lead arsenate on adults under method 1 in three experiments gave no kill; under method 4 in one experiment it gave no kill. Lead arsenate on eggs in one experiment gave no kill; also on first instar larvae in one experiment it gave no kill.

Manganar, active ingredient manganese arsenate 64 to 60 per cent, 2 pounds to 50 gallons of water. *Manganar* on adults under method 1 in two experiments gave 0 and 3 per cent kill; under method 4 in one experiment it gave 15 per cent kill. *Manganar* on eggs in one test gave no kill; also on first instar larvae in one test it gave no kill.

Paris Green, powder 1 pound to 50 gal-

lons of water and 4 pounds of hydrated lime. Paris green on adults under method 1 in four experiments gave 79 to 99 per cent kill, averaging 85 per cent; under method 2 in five experiments it gave 11 to 50 per cent kill, averaging 34 per cent; under method 3 in one experiment it gave 93 per cent kill; under method 4 in one experiment it gave 99 per cent kill; and under method 5 in one experiment it gave 7 per cent kill.

These results indicate that Paris green was very toxic to adults, especially when the adults were thirsty or were confined to plants or in cages covered with Paris green.

Paris green on eggs in five tests gave 14, 15, 0, 11 and 0 per cent kill, averaging 7 per cent. Paris green on first instar larvae in three tests gave 2, 4 and 2 per cent kill, averaging 3 per cent.

Phenothiazine with orvus, 1 per cent, at the rate of 2 pounds to 50 gallons of water. Phenothiazine on adults under method 1 in three experiments gave 100 per cent kill; under method 2 in two tests gave 100 per cent kill; under method 5 in one experiment gave 100 per cent kill; also in one test when applied as a dust diluted with talc, one part to ten of talc, gave 98 per cent kill.

Phenothiazine on eggs in seven tests gave 100 per cent kill except in two instances, in which the kill was 95 and 98 per cent. Also in three tests on newly hatched larvae the kill was 100 per cent. Phenothiazine dust, 1 part to 10 parts of talc, in one test gave 91 per cent kill.

Volck Nursery Oil, 3.2 per cent spray. *Volck Nursery Oil* on adults under method 1 in eight experiments gave 0 to 23 per cent kill, averaging 14 per cent; under method 3 in four experiments it gave 1 to 6 per cent, averaging 4 per cent; and in method 4 in two experiments it gave 0 to 3 per cent kill.

This oil spray on eggs in four tests gave 5, 0, 2 and 0 per cent kill, averaging 2 per cent. Also on first instar larvae in two tests it gave 1 and 7 per cent kill.

DISCUSSION AND SUMMARY.—The insecticide results on *Hippodamia convergens* Guer. presented in this paper were derived exclusively from indoor tests. They may be indicative of what happens to coccinellids when these sprays are employed under field conditions. Probably in the near future someone will be able to compare these results with field tests.

Of the insecticides tested phenothiazine and derris proved to be the most toxic to all stages of the coccinellid. Phenothiazine killed 95 to 100 per cent of the adults, eggs and larvae, and derris killed approximately 70 per cent of the adults, 46 per cent of the larvae and 14 per cent of the eggs. The egg mortality reported with derris is much greater, if the large number of larvae that died a short time after they hatched are included in the number of dead eggs.

Black Leaf 40 and some of the arsenicals, particularly Paris green and calcium arsenate, proved to be fairly toxic to adults especially if thristy adults were used or if adults were confined in sprayed cages with sprayed aphids. All other insecticides in the tests conducted produced an average kill of less than 25 per cent and in many cases no kill.

In general, the insecticides tested appeared to kill a higher percentage of adults than eggs or larvae.—7-18-37.

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UNDER CALIFORNIA quarantine proclamations relating to the peach mosaic disease as revised in October an embargo is placed on the entry of possible carriers of the peach mosaic disease from the infected areas in other states and on the movement of such carriers from infected areas in California. To the host list have been added apricot, almond, prune and plum trees and cuttings.

Introduction and Recovery in Florida and Louisiana of Parasites of the Sugarcane Borer

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Results of the first three and one-half years of work, beginning with 1928, in introducing South American parasites of the sugarcane borer, *Diatraea saccharalis* F., into Louisiana have been published (Holloway, Haley & Bynum 1932; Jaynes, 1932, 1933). After one more season the activities in South America were discontinued. A report of the work in Peru in 1932 and a summary of the work to January 1936 are given herein.

During 1932 a total of 46,522 adults of *Ipobracon rimac* Wolcott, mostly females, were shipped by plane from Trujillo, Peru, to Miami, Fla. Most of these were forwarded by train to New Orleans, but some were released in Florida. From these shipments 33,599 were released, the survival thus being 72.2 per cent. In one individual shipment the proportion of live material obtained was as high as 95.4 per cent. While adults of *Ipobracon rimac* were being collected, occasional adults of *Bassus stigmaterus* Cress. were encountered and were included with them in the shipments.

Adults of *Theresia claripalpis* V.d.W., formerly called *Paratheresia claripalpis* (1934), were reared from puparia in Peru and transported in the same way as the *Ipobracon* adults both to Miami and to New Orleans. A total of 13,748 flies were sent and 4,029 of these, or 29.3 per cent, survived. In one case, however, 94.3 per cent survived.

SHIPMENT OF PARASITES.—Crates made of wood and wire screen were used for shipping both the wasp and the fly in the adult stage. These containers were covered with black cloth to reduce the activity of the insects. The type of crate used for the wasp has already been described (Jaynes 1932, 1933). That used for the fly was usually somewhat larger, and contained a padding of cotton over its top so that it would retain moisture for a longer period. A smaller number of flies, usually 400 to 600, were contained in a single crate. The best food for this fly proved to be small squares of caramel candy tacked to the inside of the crate.

A total of 392,296 puparia of *Theresia claripalpis* were shipped in 1932, 364,675 by ship and 27,621 by plane. Those sent by plane were reared in the laboratory from the fly larvae collected in the field. Naturally there was a much higher emergence from these than from field-collected puparia. In one shipment the emergence was as high as 62 per cent. From all the puparia shipped in 1932, 54,476 flies were reared, or 13.9 per cent of the total number shipped. It may be of interest to note the emergence obtained in Peru from three lots of puparia. On July 5, 6 and 7, 18,144 field-collected puparia were bought and placed directly in three rearing cages, in open tins together with damp moss. The three cages gave an average emergence of 25.5 per cent. On July 7, 8 and 9, 14,566 fly puparia were bought and placed directly in an icebox, being packed in damp moss in tins. These were held in the icebox at a temperature of approximately 55° F. until July 20, when they were removed. The tins were then opened and placed in three rearing cages. From these puparia there was an average emergence of 33.1 per cent. Between September 1 and 4 the third lot, consisting of 30,637 puparia, were collected and placed in rearing cages. From these puparia 12,506 flies emerged, or 40.8 per cent.

The procedure of holding the puparia for twelve days in a cool place, as just described, apparently had no ill effect whatsoever on the resulting emergence. The still lower temperatures encountered on the ships and the prolonged time in storage, however, apparently affected the emergence considerably. The peak of the emergence in the first lot was between August 6 and 11, about one month after collection, whereas the emergence peak of the second lot was reached between August 15 and 20, slightly less than a month after their removal from the icebox, showing that development took place while the parasites were in the icebox. The emergence terminated very rapidly in all three lots. If no parasitization of the puparia occurred in the field, an emergence was obtained from field col-

lections—an emergence gradually increasing to the peak and then gradually decreasing. The older puparia, however, were found to be heavily parasitized when collected, and the emergence from them was not so good as from those recently formed and which had not been exposed to the secondary parasites except for a short period. The flies from the recently formed puparia all emerged at about the same time, which explains the height of emergence reached at the end.

A trip was made during June to the mountainous section between Cuzco and Abancay, Peru, in search of new parasites of the borer. Only eight females of an *Ipobracon* were found and these were placed in a cage with cane that had been artificially infested with borers. No parasitization took place nor were any evidences of attempt at parasitization, such as paralyzed borers, observed. These specimens were very similar in appearance to *I. rimac*, though larger, and have been identified by C. F. W. Muesebeck as a new and undescribed species of *Ipobracon*. A few empty *Ipobracon* cocoons were found within the cane stalks but none containing the parasite. Just what species was parasitic on the borer in this section was therefore not determined. Wolcott (1929) reported finding *Ipobracon abancay* Wolcott parasitic upon the borer in this section in 1928. Although considerable cane was split open and examined, no fly puparia or borers showing signs of parasitization by *Theresia claripalpis* were found. Owing to the cold climate, which reduces the number of generations per year, borers apparently do very little damage in this section. The altitude here is about 7,000 feet.

RELEASE OF PARASITES.—During the four seasons a total of 1,029,359 puparia and 13,748 adults of *Theresia claripalpis* were shipped from Argentina and Peru. From this material 161,900 flies were released. In Louisiana 157,852 were released on 21 plantations, the number of flies in individual releases ranging from 1,003 to 26,660. In Florida in 1932, 4,048 were released, 62 at one place and 3,986 at another.

During the four seasons a total of 106,154 adults and 316 cocoons of *Ipobracon rimac* were shipped from Peru. From this material 49,674 wasps were released. In Louisiana 36,735 were released on four plantations, individual releases ranging in number from 189 to 27,498 wasps. In Florida in 1932, 12,939 wasps were released on two plantations, 200 at one place and 12,739 at the other.

A total of 86 individuals of *Ipobracon tucumanus* Brethes were released in Louisiana in 1929 from 421 cocoons and 50 adult females shipped from Argentina. A shipment of 185 females and 7 males was made from Argentina in April 1930, and 36 of these arrived alive. This species has not been recovered.

RECOVERY OF PARASITES.—In 1931 nine empty cocoons, which no doubt were those of *Ipobracon rimac*, were found in Louisiana in one field where wasps had been released that year. In the fall of 1932 several cocoons of this species, some of which produced adults, were found in Louisiana in two of the three places where releases had been made that year. This species was also found in Florida in one field where it had been released in May of the same year.

In September, 1934, Messrs. Ingram, Bynum and Jaynes, in searching for parasites of the sugarcane borer at Canal Point, Fla., where *Iprobracon rimac* and *T. claripalpis* had been released in 1932, found eight empty cocoons and a fragment of an adult wasp. These cocoons were identified by the author as those of a species of *Bassus* and the fragment was determined as such by C. F. W. Muesebeck.

During the last part of August and the first part of September, 1935, in fields at Canal Point near the place where parasites had been released in 1932, the author found five empty cocoons, two cocoons containing parasites, and 14 parasitized borer larvae that later produced adults of *Bassus stigmaterus*. Apparently the very few adults of *Bassus* included in the *Ipobracon* shipments were able to establish themselves. One reason, perhaps, why this species was able to become established from a very small number is the fact that it reproduces parthenogenetically, no males having ever been found. This species has never been recorded as parasitizing a very high percentage of borers in any country in which it occurs. In Florida as high as 15.38 per cent apparent parasitization was obtained in one field, while the highest percentage of

parasitization ever found by the writer in Peru was 9.7. It appears that this parasite is fairly well established at this one point. Time did not permit examination of cane over other parts of the plantation for the possible presence of parasites.

Three empty cocoons and 13 live borers were found in January, 1936, in a few hours examination of cane at Canal Point. These borers were kept and one individual of *Bassus stigmaterus* emerged from them.

Theresia claripalpis has never been recovered in Louisiana or Florida except for one puparium found, in the fall of 1932, on a plantation in Louisiana where flies had been released that year. J. W. Ingram and the writer found 21 fly puparia in a field of sugarcane while searching for borer larvae on Pennock Plantation, Jupiter, Fla., on January 25, 1936. The flies had emerged from 13 of these. Six flies were reared from the remaining eight puparia. These flies do not appear to agree exactly with *claripalpis*. However, there is a tendency toward intergradation with specimens from Argentina and Peru, and it is considered unwise at present to declare definitely that a distinct species is represented here.

SUMMARY.—Three species of parasites from South America; namely, the dexiid fly *Theresia claripalpis* V.d.W. and the wasps *Ipobracon rimac* Wolcott and *Bassus stigmaterus* Cress., have been released in Louisiana and Florida in an attempt at biological control of the sugarcane borer, *Diatraea saccharalis* F. Recoveries of *B. stigmaterus* have been made in Florida.—6-1-37.

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Conditions Affecting Mosquito Breeding, with Special Reference to *Aedes thibaulti* Dyar and Knab (Diptera, Culicidae).[1]

S. E. SHIELDS[2] AND JAMES B. LACKEY[3]

One of the duties of the Tennessee Valley Authority is to safeguard the health of the people of the Tennessee Valley. Malaria control is a great health problem here as in other navigation, flood control and hydroelectric developments in the South, for its principal vector, *Anopheles quadrimaculatus* Say, breeds in abundance in the waters impounded by the dams unless special precautions are taken (Stromquist 1935; Bishop 1936). Attempts to control this vector have resulted in careful studies of the selectivity exercised by mosquitoes in the choice of their breeding places. All known ponds or bodies of water in the vicinity of the Tennessee Valley Authority's lakes have been investigated for the breeding of this species, for top-feeding minnows, for insects and other predators, for plants which might affect mosquito breeding and for other factors allied to the work.

In the course of the work it was found that a tupelo gum pond about six miles from Wilson Dam, known as Gum Pond, abounding in hollow trees and stumps, many with holes suitable for mosquito breeding, fig. 1.

[1] A contribution from the Health Section of the Tennessee Valley Authority, Wilson Dam, Alabama.

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As this pond is easily accessible and on a main road between Wilson and Wheeler Dams, the holes were numbered and frequent stops were made in the early spring of 1936 to search for breeding. During an investigation on March 13, 1936, larvae identified as *Aedes thibaulti* Dyar and Knab, were secured from a pool inside the base of a hollow tree. Since few records are available on this species it was decided to make as complete a study of the breeding habits as possible.

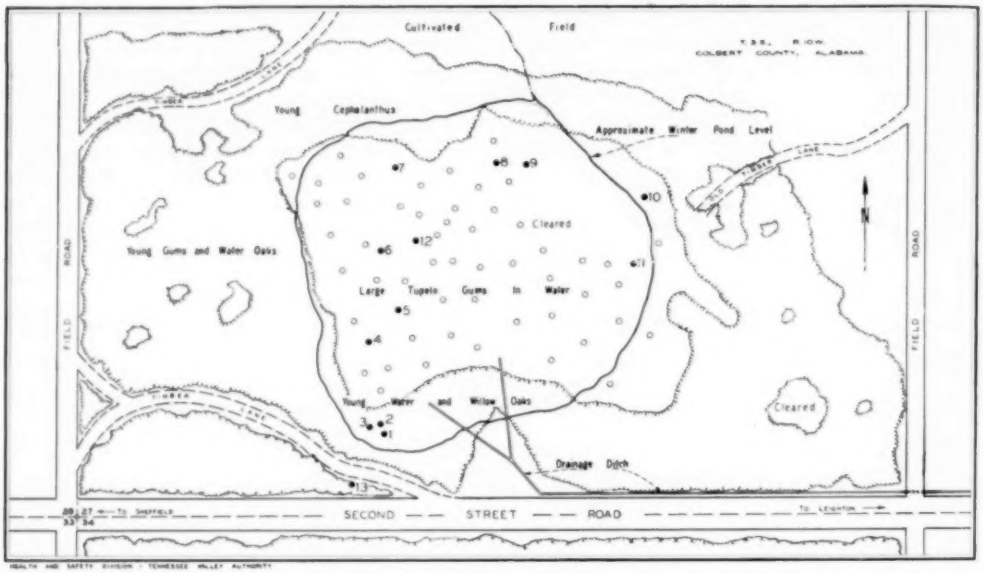

FIG. 1.—Sketch map of Tupelo Gum Pond showing location of vegetation growths.

BREEDING PLACES.—This species exhibits a decided restriction in its choice of breeding places as far as our observations in the Tennessee Valley show, for *Aedes thibaulti* adults were taken in only three places, namely: Gum Pond, a second pond near Leighton, Ala.,[4] and near a "blue hole" or deep limestone spring in a tupelo swamp at the head of Beaver Dam Creek, Madison County, Ala. Larvae were taken only at Gum Pond and the Leighton Pond.

The first two ponds were essentially the same type except that the Leighton pond was larger and shallower than Gum Pond, contained less small vegetation, was frequented in the spring by water fowl and later, as it dried out, by cows and mules. The larvae from both locations were found inside the base of hollow trees or stumps. The third pond was in reality a small stream 10 to 15 feet wide coming from a large limestone spring or "blue hole" which meandered for a mile or more to form the headwaters of Beaver Dam Creek. A dense border of tupelo, buttonwood and willows, varying in width from a few yards to a quarter of a mile, occurred along the entire distance.

In the course of much field work, numerous other tree holes and hundreds of temporary pools, as well as ponds, streams and other possible breeding situations, were investigated. Numerous other larvae were collected, especially from tree holes, but none of *A. thibaulti*, nor were adults of this species collected in six light traps operated by the Health Section in the Muscle Shoals Area.

This paper almost entirely concerns the work done at Gum Pond, with only a few observations from other sources. It was chosen as a place to carry on the studies, as other mosquitoes were also being studied there, and as it was easily accessible to the laboratory.

GUM POND.—The Gum Pond breeding place is an old lime sink on top of a hill. The original sink has silted up so that only a shallow pond exists. It covers two acres at its maximum extent, but its normal area is only half an acre. Its only

[4] Collected by Noah Aston, Junior Biologic Aide, Tennessee Valley Authority.

water supply is surface drainage from approximately 50 acres of plowed fields. In exceptionally dry years it disappears by late June, as it did in 1936. That the sink is at least 200 years old is indicated by rings on the stumps. Its center is occupied by a grove of tupelo gum (*Nyssa aquatica*) and its margin by smaller trees, mostly willows, water oaks and post oaks. Buttonwood (*Cephalanthus occidentalis*) forms a marginal fringe, and the muddy area exposed by the receding water is quickly invaded by *Polygonom*, *Bidens* and grasses. Aquatics are principally *Naias flexilis*, *Myriophyllum heterophyllum* and a species of *Ranunculus*.

The tupelo gums are especially interesting in that their bases are usually expanded and hollow. Some of these hollows connect with the water of the pond, but some have openings too high up to do so. There is not a connection in all cases, as is shown by differences in water level inside and outside the stump or hollow tree. The bottom of all holes is approximately level with the bottom of the pond and cannot be considered as tree holes in the true sense of the word with the exception of no. 13. Some 20 holes were found in a small area either in living trees or stumps.

There are no fish in the pond, although salamanders, frogs, turtles, snails, insects and Crustacea are abundant. Predacious insects found in large numbers are: Odonata, Dytiscidae, Gyrinidae, Hydrophilidae, Nepidae and Gerridae. It is not known to what extent these influence the breeding of mosquitoes in a given habitat, but it is significant that the holes from which mosquito larvae were taken have not shown large numbers of these predacious insects although one hole was open to the pond a part of the time. It was particularly noted, however, that their numbers were relatively low in this hole which produced mosquitoes abundantly.

The pond is carpeted with dead leaves and weeds. Around the margin these tend to be coated with ferric hydroxide, and filamentous iron bacteria are plentiful; the latter also abound in the tree holes. A number of larvae were taken with curious humps on their breathing tubes which were found to be masses of iron bacteria and their secretions. There is no pollution of the water, but each rain washes in much silt so that a permanent colloidal condition exists. A very large protozoan plankton is found, but only a small quantity of diatoms and filamentous algae. In the late spring of 1936, the number of plankton species decreased; by May 20 *Euglena polymorpha* constituted about 99 per cent of the surface plankton, forming a green scum on the water.

The temperature rose to 16° C. as early as March 4 and continued high until the pond dried. At that time the pH was 6.0 but by May 20, it had risen to 6.4. No chemical analyses or oxygen content determinations were made. The pH values preclude the possibility of the presence of saline ammonia which Senior-White (1928b) thinks detrimental to the breeding of natural water breeders.

Detailed observations were made on this pond because it was thought to produce *Anopheles quadrimaculatus*. Until May 23 the only mosquito which was found breeding in the pond was *Aedes vexans* (Meigen), a single brood of these having occurred along a 50-foot stretch of shore line on March 31. From May 23, sparse breeding of *Culex apicalis* Adams, *Uranotaenia sapphirina* (Osten-Sacken), *Anopheles quadrimaculatus* and *Anopheles punctipennis* (Say) was found and became heavier as the season advanced. This was to be expected; it is far easier to account for the breeding then for the lack of it.

Nevertheless the tree and stump holes in the pond had been breeding places for six species of mosquitoes prior to May 23. Four holes produced *Aedes thibaulti* and along with it in one or more holes occurred *Culex restuans* Theobald, *Culex apicalis* and *Theobaldia melanura* (Coquillett). The most abundant breeder was probably *Aedes triseriatus* (Say), found in six other holes, the roadside ditch and a hole about 20 feet from the pond where a stump had been removed. Table 1 gives a brief summary of breeding and environmental conditions for the pond and tree holes which show breeding. All holes were in tupelo gum stumps or trees except no. 7, which was in a black gum (*Nyssa biflora*) and no. 13 which was in a sweet gum (*Liquidambar styraciflua*). Only hole no. 4 (fig. 2) had a definite connection with the pond, but hole no. 1 was covered by the pond for some time after a heavy rain, and thereafter its flora and fauna (microscopic) resembled that of the

pond. Table 1 gives no indication why *A. thibaulti* failed to breed in all holes, and

FIG. 2.—Hole no. 4. White lines show maximum water level.

there is no clue in the plankton content of the holes, which was carefully studied. In only one or two cases was there a limited plankton, and differences in plankton species were hardly significant. Furthermore, larvae came to pupation in holes where their numbers were so great as practically to exhaust the plankton content. This was true of no. 13; the water was so brown, probably from the decomposition of the wood, that its pH could not be taken colorimetrically; it was teeming with larvae, but there were few Protista, and the digestive tracts of the larvae showed few or no remains of Protozoa or Algae.

PERIOD OF OCCURRENCE.—The larvae of *Aedes thibaulti* were collected from March 13 to May 25. The number of small larvae diminished rapidly during the latter part of April; at the same time, the pupae increased rapidly until they reached their maximum numbers around May 6. The brood then came off rapidly as the weather grew warmer. The first adult was observed on March 24. From that time until May 10 the males predominated in numbers and attained the

Table 1.—Environmental relations in twelve possible breeding situations for *Aedes thibaulti*.

SITUATION	MOSQUITOES PRESENT	pH RANGE	TEMEPRATURE RANGE	WATER COLOR	LIGHT	PLANKTON
Pond	*A. vexans* *C. apicalis* *A. quadrimaculatus* *A. punctipennis* *U. sapphirina*	6.0–6.4	11.5–21° C.	Silty yellow	Varied	Abundant
Pool	*A. vexans*	6.2	17° C.	Clear	Shaded	Abundant
Hole No.						
1.	*C. restuans* *A. triseriatus*	5.8–6.3	11–19° C.	Clear to silty	Partly shaded	Abundant
2.	*A. triseriatus*	6.0–6.2	13–15° C.	Clear	Shaded	Abundant
4.	*A. thibaulti*	6.0–6.4	11–17° C.	Silty	Dark	Sparse
7.	*A. thibaulti* *C. apicalis* *T. melanura* *A. triseriatus*	6.1–6.3	15–16° C.	Clear brown	Some shade	Sparse
8.	No breeding	6.0–6.2	17–19° C.	Clear	Some shade	Sparse
10.	*A. thibaulti*	6.0–6.2	12–15° C.	Clear	Some shade	Abundant
11.	*A. thibaulti*	5.8–6.0	12–15° C.	Clear	Some shade	Abundant
12.	No breeding	6.0–6.2	14–17° C.	Clear	Some shade	Sparse
13.	*A. triseriatus* *A. barberi* *O. alba* *O. signifera*	Not taken	18–20° C.	Dark brown	Some shade	Scarce
15.	*A. thibaulti*	6.0	Not taken	Clear	Some shade	Scarce

NOTE: In addition to these species, adults of *Psorophora ferox* (Humboldt) and *Psorophora cyanescens* (Coquillett) were taken in the area but were not found breeding in any of the places examined.

majority of approximately 2 to 1 by April 24; then decreased in proportion until only an occasional one appeared late in May. The maximum numbers, including both sexes, occurred around May 15. The numbers remained fairly steady until June 9; then dropped off rapidly until only a few could be found on June 26, and none after the first few days in July.

These observations indicate the species occurs in northern Alabama from early March through July 15. The height of emergence occurs in early May and the adults remain in the woods for a month or more laying eggs which hatch the following spring. There seemed to be only one brood, and it is assumed that the species passes the late summer and winter in the egg stage.

The adults prefer to rest in the darkened hollows of trees and stumps during the day, but several were noticed flying and biting in the daylight in the shade of the tupelo gums. Observations were made on their numbers by searching their resting places with a flashlight. A conservative estimate would exceed an average of 50 per stump or hollow tree at the time they were most abundant. Less than 10 per cent of all mosquitoes found resting in these places belonged to other species found in the vicinity.

COLLECTION AND REARING METHODS.—In order to obtain records on the development of this species, it was thought desirable to rear individuals in the laboratory under conditions as nearly natural as possible. Larvae were taken from holes from which they could be dipped out. Holes too small for a dipper were checked for breeding by using a flashlight and also by sucking water out through a glass tube which had a large rubber bulb attached.

Surplus water from each dip was poured off; then the larvae, settled debris and plankton were transferred to eight ounce specimen bottles. No mortality was experienced from transporting them six miles in a compartmented case.

As many of the larvae were taken from the collections and reared in individual tubes as time would permit. Individual larvae were isolated from the field collection with a large mouthed pipette and transferred to test tubes containing about 15 cc. of the agitated water from the hole, thus giving as much of the plankton as possible. This procedure was followed with most of the larvae and was sufficient to insure the emergence of those in the fourth stage.

When rearing larvae from earlier stages the addition of fresh plankton was necessary at intervals. The addition of plankton was preceded by removing, with a pipette, as much of the tube's contents as possible without stranding the larvae, then adding fresh plankton up to the old level. In this way the concentration of organisms was higher than if plankton had been added to the depleted water and the waste products remaining were correspondingly lessened.

LENGTH OF LARVAL AND PUPAL PERIOD.—In order to determine the time necessary for development, 12 first stage larvae were secured on April 9. These larvae were placed in individual tubes; then 15 cc. of water with the natural plankton added and the rack containing them placed in a white canvas covered and shaded cage outside the laboratory. Every two days some plankton was obtained from the tree hole whence the larvae were procured and added up to the former level, after most of the water from the previous feeding had been removed.[5] Because of cold weather, growth was rather slow until the last week of April. At that time the weather became warm, and by May 7 the larvae were removed into the laboratory where it was cooler and more nearly the temperature of their natural environment. Feeding was continued here as usual, and on May 18 the first larvae pupated; by May 28 all had emerged.

The average length of the larval period, based on the pupation of eight larvae, was 42 days, with a maximum of 46 and a minimum of 39. All eight of the pupae emerged as adults. They had an average pupal period of 3 days with a maximum of 4 and a minimum of 2.

It may be added that the first two specimens emerging were males and the remainder females. The percentage of males emerging from March collections was high, with a tendency for later collections to decrease gradually. This fact of more rapid development of males was also noted in *Aedes canadensis* (Theobald).

[5] Mr. Noah Aston did much of this work.

FOOD OF THE LARVAE.—Specific food organisms probably are not a factor in the selection of breeding situations. Careful attention was given to the methods of larval feeding in the test tubes, to the recognizable food material in the digestive tracts of 21 larvae and to the microorganisms present in the breeding holes. In the laboratory the larvae feed at both top and bottom, and apparently ingest any particle which can be swept in. Verification of this is indicated by the recognizable remains from the guts of the 21 larvae dissected, as shown tabulated below in table 2.

Table 2.—Recognizable remains from the guts of 21 dissected larvae of *Aedes thibaulti*.

RECOGNIZABLE REMAINS	NO. LARVAE IN WHICH FOUND
Copepod remains	4
Ciliate remains	5
Green algae, non-filamentous	5
Green algae, filamentous	5
Pollen	5
Blue green algae	6
Diatoms	6
Soil particles	11
Spores of fungi	17
Flagellate protozoa	19
Amorphous brown matter	21

Senior-White (1928a) reviewed the literature on the food preference of Anopheline larvae and, after including his own work, decided that they are general feeders. One of us (Rudolfs & Lackey 1929) has secured high emergence and pupation results with practically pure cultures of various protozoa and algae, using three species of Culicine larvae, but all field work indicates general rather than specific feeding habits. The Gum Pond tree and stump holes contained 109 recognizeable species of Protozoa, including 35 species of Euglenidae. About 25 species of Protozoa, including 6 species of Euglenidae, were found in the holes yielding *A. thibaulti*, and a few species were recovered from gut examinations which were not found in the water whence came the larvae. Because of the predominance of Euglenidae it was thought for a time they might constitute a favored food group, but this was not substantiated. One curious fact noted was that certain Euglenidae, notably *Trachelomonas euchlora*, were alive in the extreme posterior end of the gut and, on being freed by dissection, slowly recovered their motile powers and were apparently viable. After first noting this, special precautions were taken to see that these living forms were not accidently introduced in the dissection water, and the fact was noted several times thereafter.

No quantitative records were kept either as to gut contents or as to the numbers of Protozoa present in the water. Desmids were lacking; diatoms practically so and *Chlamydomonas* were very rare. The principal flagellates eaten appeared to be Euglenidae, but they are the ones most resistant to disintegration, especially the loricate forms. Some of the larvae contained all 11 classes of possible food materials listed above.

FIG. 3.—*Aedes thibaulti* in acting of biting.

BITING HABITS.—The females made no effort to bite until May 12, although they had been fairly abundant for almost a month and feeding opportunities had been repeatedly offered. The first attack was made while a collector was dipping larvae from the bottom of a hollow stump. The collector was very hot and sweaty, but had taken dips from that stump several times before under the same conditions without inducing the mosquitoes to bite. No difficulty was encountered in inducing them to bite after May 12 until June 2 when an attempt was made to obtain a picture of one feeding, fig. 3. The biting diminished from June 2 until the last feeding record on June 26.

When the collector's arm was exposed near the resting place, the mosquitoes would not come out to feed in a swarm, but would come out singly or in pairs. At one time 30 specimens were collected in approximately as many minutes by taking them off the arm as they inserted their proboscides.

The bite is relatively painful and induces a moderate swelling. It may be compared to the bite of *Aedes canadensis* or *Aedes hirsuteron* (Theobald), is more painful than the bite of *Anopheles quadrimaculatus* and less painful than the bite of *Anopheles punctipennis, Aedes sollicitans* (Walker), *Aedes taeniorhynchus* (Wiedemann) or any of the *Psorophora.*

DESCRIPTION OF *Aedes thibaulti.*—The larvae and adults of *Aedes thibaulti* have been adequately described in previous papers; so it is not necessary to include a detailed description here (Bradley 1925, Dyar & Knab 1910). One difference in the larvae was noted which seems worthy of mention.

The lateral abdominal tuft on the sixth segment consists of a single hair. There was no exception on the specimens examined from Wilson Dam. The lateral abdominal tufts are, therefore, multiple on segments 1 and 2, double on 3, 4 and 5 and single on 6.

The adults are easily identified in the field from other Alabama mosquitoes by the contrasting yellow and black pattern on the mesonotum and by the lack of tarsal bands. The yellow pattern on the mesonotum covers the anterior half, except for the well defined longitudinal black mid-line, ends abruptly about the middle and is present again only in a patch just anterior to the scutellum. The male genitalia were not found to differ from those of previously published descriptions.

SUMMARY AND DISCUSSION.—The observations indicate that *A. thibaulti* is a single brooded woodland species which can be collected as larvae from early March to late May in the water in the base of hollow trees and stumps and as adults from late March to early July in the darkened corners of the larval habitat.

The larval period varies from 20 to 50 days, according to the temperature and food; the pupal period from 2 to 4 days; the adults live for over a month in some cases.

Although breeding is restricted to specific places, three other species were found breeding with *A. thibaulti.*

The species is not a vicious biter, but the females could be induced to bite during most of May and June.

The restriction of this species to holes

FIG. 4.—Tree base open to pond.

in hollow trees and decaying stumps is interesting. The environmental conditions of woodland pools, ponds and stump holes have been carefully studied in endeavoring to find the specific determining factor in this case. The principal differences appear to have been temperature, light and the presence of presumable predators.

The temperatures of all the breeding situations have been lower than the pond. Thus on March 18, the pond had a temperature of 18° C., but hole no. 4 had a temperature of 11° C.; on March 31 the temperature of the hole was still 11° C., but that of the pond was 20° C. This same condition has been true of the other holes examined; their temperature being consistently low during the entire study.

The breeding situations also had a diminished light. No instrument was available for determining the comparative intensities, but hole no. 4 had a very greatly reduced light, whereas hole no. 7 had much more, somewhat comparable to the amount in the pond. If

the amount of light had been the determining factor, breeding might reasonably have been expected inside some of the huge tree bases which were open to the pond, fig. 4, These situations were carefully examined from time to time and no *A. thibaulti* were found. Some of the other holes likewise having reduced light showed no breeding.

The last observation applies to the presence of certain predatory insects or their larvae; some of the stump holes without predators showed no breeding, despite the fact that predatory insects were lacking. The pH of these holes was comparable to that of the pond, and while some of those in living trees might have had a higher tannic acid content than others, this could not be checked.

The plankton of the holes was varied and often plentiful. After a site began to breed, however, its plankton content decreased quickly until often very few protozoa or algae could be found. Thus, in the water of hole no. 15, practically no Trachelomonas were found, yet larvae of *A. thibaulti* from there showed this organism in abundance in gut contents.

From these studies of its environment it is apparent that the factors operative in the selection of breeding places are not discernible for this mosquito.—9-18-37.

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Resistance of Certain Corn Hybrids to Attack of Southern Corn Rootworm

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Southern corn rootworm, *Diabrotica duodecimpunctata* (F.), is a common pest of corn in the corn belt area of Illinois. During wet seasons, and years following the wet seasons, according to Metcalf & Flint (1928), it is frequently responsible for losses amounting to 25 per cent of the plants when they are 6 to 18 inches tall, or midseason lodging of 40 to 50 per cent of the plants followed by reduced production and lower quality of the crop. These losses are especially important in the central and south-central sections of Illinois shown in fig. 1.

Midseason damage caused by southern corn rootworm develops primarily through pruning of roots and secondarily through development of root-rots following pruning. These effects are evidenced by delayed tasseling, silking and maturity, and by lodging of plants. Lodging will occur independent of wind damage, but root pruning and subsequent rotting intensify wind damage. Forbes (1894) in 1892 made the following significant observations on southern corn rootworm: "As a consequence of the loss of roots and the general weakening of the plant, many stalks fail to set the ear, or form only a nubbin. The injured plant also matures slowly, remaining green longer than the average, and being thus especially subject to injury by frost." Furthermore, corn badly lodged following severe root-

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worm damage cures so slowly that harvesting was delayed from one to two weeks.

The southern corn rootworm is not controlled by rotation or introduction of generally accepted farm practices. In fact, it is frequently more destructive on farms of the most progressive farmers. Damage occurs earlier and extends over a greater part of the growing season than does that of the corn rootworm, *Diabrotica longicornis* (Say) a similar insect which is important where corn is grown on the same field for two or more years in succession and whose attack is controlled by rotation.

During the fall of 1927 the authors observed differences in the resistance to lodging of corn varieties and hybrids following heavy rootworm attack in an experimental plot in Morgan County, Ill. Unfortunately, this observation was not followed by experiments designed to study the reaction of different varieties and hybrids to injury from rootworm attack.

MATERIAL USED FOR STUDY.—During 1935 a severe outbreak of southern corn rootworm occurred in a widespread area in the corn belt section of Illinois. General extent and intensity of this outbreak, as determined by surveys made during the summer, are shown in fig. 1. The fact that many of the state corn performance test fields, other experimental field plots and cooperative strip tests were infested made it possible to study the behavior of a large number of inbreds, top crosses, hybrids and varieties during and following attack of this insect.

Each corn performance field consisted of approximately 60 entries, both open-pollinated varieties and hybrids, planted in plots 2×12 hills and replicated 10 times in random distribution. A few experimental hybrids were replicated only five times. For the most part, entries in the three different fields which each section contained were the same, but varied in the different sections.

Many strip test plots, mostly in the central section, were also under observation during the season. These tests were planted by farmers with their own equipment in regular corn fields. They consisted of four rows each of certain hybrids and open-pollinated varieties of corn planted adjacent to each other and usually planted in the center of the field.

Additional observations were made and data taken on University of Illinois soil fields at Hartsburg, Carthage and Kewanee, fig. 1. Breeding plots and experimental yield plots for top-crosses and hybrids in the United States Bureau of Plant Industry plots near Bloomington, some of which were heavily infested, were also used in these studies.

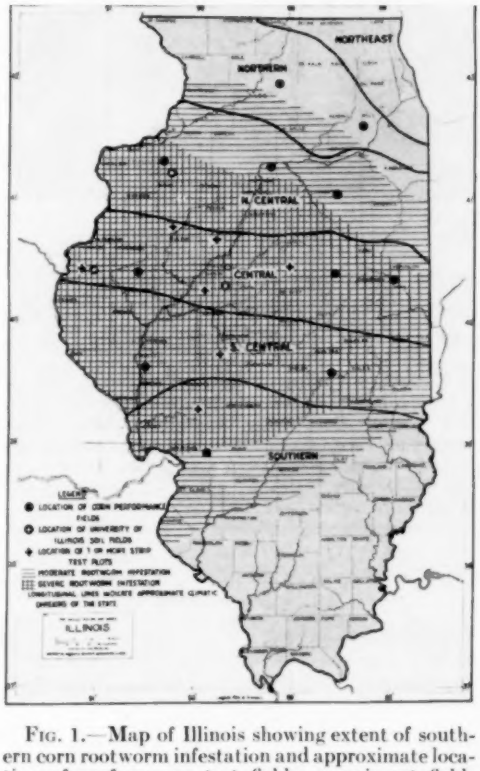

FIG. 1.—Map of Illinois showing extent of southern corn rootworm infestation and approximate location of performance test fields, experiment fields and strip test plots, summer, 1935.

SURVEY OF ROOT EXAMINATIONS.—Severe and widespread damage by southern corn rootworm was observed throughout central Illinois, July 10–15, 1935. At that time the roots of much of the corn in the south-central section has been severely pruned and some of the plants were lodged and wilting, see fig. 2. Examination of breeding plots in the vicinity of Bloomington the last two weeks in July showed wide variation in the amount of lodging in inbreds and top-crosses, and indicated that some of them were recovering from the injury caused by rootworm. During the next few weeks many plants of hybrids and open-pollinated varieties

were dug to determine the extent of damage and reaction to root pruning. These examinations showed that many hybrids were recovering from rootworm attack

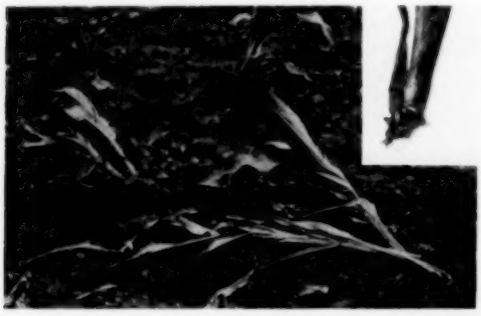

FIG. 2.—Typical condition of corn following severe attack by southern corn rootworm, July, 1935. Inset shows close-up of root of one of these plants.

much more rapidly and much more successfully than other hybrids and locally used open-pollinated varieties, fig. 2.

Table 1.—Percentage of plants lodged, August 3 and August 29, in two groups of hybrids (A and B) and one group containing three open-pollinated varieties in a field only moderately infested with southern corn rootworm, State Normal University Farm, Normal, Ill., 1935. (Each percentage based on 1,500 plants.)

KIND OF CORN	PERCENTAGE OF PLANTS LODGED	
	Aug. 3	Aug. 29
Hybrids—Group A	19.7	3.1*
Hybrids—Group B	39.9	20.5*
Open-Pollinated Varieties	62.1	62.7

* Reduction in amount of lodging highly significant statistically.

Rapid recovery, regaining of erectness with very little elbowing and capacity of plants of certain hybrids to remain erect were apparent in early August. Some representative data are given in table 1.

One group of hybrids (A) decreased in lodging from 19.7 per cent on August 3 to 3.1 per cent on August 29, table 1. Another group of hybrids (B) was lodged more on August 3 than group A and recovered less; 39.9 per cent on August 3 and 20.5 per cent on August 29. In this particular experiment, open-pollinated varieties were lodged as badly on August 29 as they were on August 3. Some recovery had taken place among all three groups prior to August 3. Only plants that regained erectness with no conspicuous elbowing were classed as erect on the second date.

Additional data on rate of recovery in one of the heavily infested fields are given in table 2. Typical roots were washed out and photographed during the second week in August. In general, plants of open-pollinated varieties were found to vary greatly (1) in extent of root systems and, (2) in character and amount of

FIG. 3.—Roots of individual corn plants growing in close proximity to each other in field where damage by the southern corn rootworm was severe. Bloomington, Ill., August, 1935. Above are roots of an open-pollinated variety Below are roots of a resistant hybrid.

branching, prior to and following rootworm pruning, fig. 3. While some plants of open-pollinated varieties had practically no roots left, other plants had developed new roots almost as rapidly as they had been eaten off so that the plants

Table 2.—Percentage of plants lodged, August 2 and November 21, in an open-pollinated variety and a good hybrid in a field heavily infested with southern corn rootworm, Damon Farm, near Normal, Ill., 1935. Data are from a strip test conducted by the Agricultural Department of the Normal Community High School. (Each percentage based on approximately 700 plants.)

KIND OF CORN	PERCENTAGE OF PLANTS LODGED	
	Aug. 2	Nov. 21
Local Open-Pollinated Variety	92.9	61.8
Good Hybrid	40.0	10.1

apparently suffered very little from this insect attack. Almost all plants of the hybrid shown in fig. 3 had more roots, more extensively branched, than the best of the open-pollinated varieties. Roots of this better hybrid also were

characterized by profuse branching above the point of insect pruning.

RESULTS OF ROOT EXAMINATIONS.—Data taken in August during the survey and given in table 3 show that in general the hybrids in these tests were lodged much less following southern corn rootworm attack than were the open-pollinated varieties with which they were compared. Most of the hybrids used in these strip tests were those that had good performance records in previous years for yield and for capacity to remain erect until harvest time. Other hybrids in these tests were new combinations of inbreds of recognized merit in top crosses. and involved no inbreds conspicuously weak for lodging resistance in general. Hybrids of this group having the most lodging in August were found to stand uniformly better than the best open-pollinated varieties. The hybrids, however, differed significantly in their reaction to rootworm attack; only a few came through the season in heavily infested fields with less than 5 per cent lodging.

Table 3.—Summarized data on lodging in hybrids which appeared in two or more strip tests and in adapted open-pollinated varieties, data taken during survey in August, 1935.

KIND OF CORN	TOTAL NUMBER OF PLANTS OBSERVED	PERCENTAGE OF PLANTS LODGED
Hybrids	13,838	15.8
Open-pollinated varieties (*Local Illinois varieties*)	12,129	43.8

More pronounced differences in reaction to rootworm injury became evident during September. Root examinations then and later indicated that rotting followed root pruning as an important complicating factor. Plants standing the latter part of September and early October in fields heavily infested with southern corn rootworm were those whose root systems had not only been renewed by branching above the point of pruning but those that had also resisted rotting following severe pruning. These differences are illustrated in figs. 4 and 5. Roots of some plants neither branched following pruning nor rotted, roots of other plants branched but rotted badly before maturity. An effective combination for yield of sound corn under heavy rootworm infestation, however, was the combined capacity in the same plant to renew the root system rapidly following pruning and to resist subsequent root rotting.

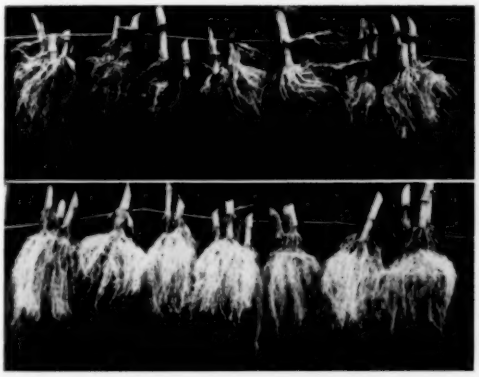

FIG. 4.—Showing recovery of a good hybrid corn (below) as compared to the failure to recover of a susceptible open-pollinated variety (above). Bloomington, Ill., October, 1935.

CORN ON HIGHLY IMPROVED SOILS.—Contrary to general belief, lodging of corn may sometimes be greater on highly productive soil than on less productive or poorly managed soils, especially when a heavy infestation of the southern corn rootworm is involved. Unpublished lodging data from experimental fields in 1927 and field observations during the 1935 season bear out this statement.

Data secured during 1935 from the Hartsburg soil experiment field located near Hartsburg (Logan County) are presented in table 4. This field is owned and operated by the University of Illinois. Although these data represent only one year's work, their consistency in first and second year corn, as well as their general agreement with field observations and 1927 data, make them highly significant. Soil treatments represented in table 4 were established on their respective areas in 1913 and have been continued to the present time, a period of 23 years, to the time the data were taken. Each respective area has had time to establish itself more or less in equilibrium with its environment, thus being comparable with conditions that exist in actual practice.

As an average of all treatments, 52.2 per cent of the open-pollinated variety was lodged in the first year corn and 41.9 per cent in the second year corn. Although the hybrid strain used was not outstand-

FIG. 5.—Comparative condition of a resistant hybrid and a susceptible open-pollinated variety of corn growing in adjacent plots under severe attacks by the southern corn rootworm. Bloomington, Ill., October, 1935.

ing in rootworm resistance, being among the lower third in lodging resistance under rootworm infestation, it had only 20.6 per cent and 20.5 per cent lodged plants, respectively, in first and second year corn. On untreated land, first year corn, the open-pollinated variety was 41 per cent lodged, the hybrid only 13 per cent lodged. Based on the open-pollinated variety, this was a reduction of 68.3 per cent in lodging. On land treated with manure, limestone and phosphate the open-pollinated variety was 68 per cent lodged and the hybrid only 27 per cent lodged, a reduction of 60.3 per cent. Both entries had more lodging on the treated land than on the untreated land. In the open-pollinated variety, however, the increase in lodging was greater than it was in the hybrid, thus emphasizing the greater need of lodging resistance, in this case, on highly fertile soil. The same relationship holds true in the second year corn. It is also reflected in the corn yields, which were 50 and 57 bushels an acre for the open-pollinated variety and hybrid, respectively, on untreated land, and 62 and 73 bushels an acre, respectively, on the fully treated area.

SUMMARY.—The southern corn rootworm, *Diabrotica duodecimpunctata* (F.), is an important pest of corn in Illinois during certain seasons.

Preliminary observations on the dif-

Table 4.—Percentage plants lodged under heavy infestation of southern corn rootworm in an open-pollinated variety and one hybrid on four soil plots, University of Illinois soil field, near Hartsburg, Ill., 1935.

SOIL TREATMENT	PERCENTAGE PLANTS LODGED			
	In First Year Corn		In Second Year Corn	
	Open-Pollinated Variety	*Hybrid*	*Open-Pollinated Variety*	*Hybrid*
Check (no treatment)	41.0	13.0	35.5	15.0
Manure	39.5	16.0	39.5	18.0
Manure and lime	60.5	26.5	41.5	24.5
Manure, lime and phosphate	68.0	27.0	51.0	24.5
Average	*52.2*	*20.6*	*41.9*	*20.5*

ferential response of strains of corn to attack by this insect were made in 1927. During 1935 a more extensive study was possible. It was clearly shown that corn hybrids in general were more resistant than local open-pollinated varieties. Some hybrids are more resistant than others.

An important factor in the resistance of strains of corn to the southern corn rootworm is shown to be their ability to recover, following damage by the insect. The relation of root pruning by this insect to root-rots which follow this attack, and resistance to this rotting by certain strains are other factors.

Corn on soils in a high state of fertility will lodge more extensively than will corn on lower fertility levels.

This is a preliminary report on resistance of corn to the southern corn rootworm. Further studies will undoubtedly reveal other factors responsible for the resistance which is here shown to exist.—10-11-37.

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The Strawberry Root Weevil as a Pest of Conifers in Nursery Plantings*

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The strawberry root weevil, *Brachyrhinus ovatus* (L.), has been reported frequently as a pest of strawberries from various parts of the United States and Canada as well as of a wide variety of evergreens in both the United States and Europe. This insect has proved particularly troublesome to coniferous trees in some nursery plantings located in western New York and has been found either in the larval or adult stage on many different host plants. The experimental work reported here deals particularly with its occurrence on and injury to transplanted trees in the nursery.

CHARACTERISTICS.—The insect belongs to the family *Curculionidae*, subfamily *Otiorhynchinae*. In central and western New York the genus *Brachyrhinus* is also represented by several other closely related species, of which the black vine or cyclamen weevil, *B. sulcatus* (F.), the alfalfa snout beetle, *B. ligustici* (L.) and the rough strawberry weevil, *B. rugosostriatus* Göze, are most commonly known. Of these, *B. sulcatus* and *B. rugosostriatus* may be associated with *B. ovatus* on strawberries, while on nursery stock *B. sulcatus* and *B. ovatus* frequently infest the same planting of evergreens, especially *Taxus*, and may even occur on the same tree. Thus far the alfalfa snout beetle, a European species recently observed in New York as a pest of alfalfa in Oswego and Jefferson Counties, is not, to our knowledge, a pest of evergreens in this locality.

The strawberry root weevil is a general feeder. Downes (1922), Mote & Wilcox (1927), Treherne (1914), Wilcox *et al.* (1934) have recorded it from the Pacific Northwest as attacking a wide list of host plants. Among these are strawberry, raspberry, loganberry, blackberry, cranberry, grasses, clover, crucifers, cucurbits, deciduous trees, shrubs, various kinds of seedlings and young trees. Patch (1905) mentions it as a household pest in Maine and Whitcomb (1931) points out that it is injurious to Japanese yew, *Taxus cuspidata*, in New England where "occasionally at least 50 per cent of the nursery plantings of *Taxus* have been infested and injured, as well as isolated specimens in ornamental plantings."

The work reported in this paper has dealt primarily with the control of the strawberry root weevil as a nursery pest rather than with an extended study of the host plants. However, the following host records of the larvae or adults have been obtained, some of which were reported

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in an earlier paper (Gambrell 1937): Norway spruce; white spruce; Colorado spruce; Servian spruce; Austrian pine; Scotch pine; red pine; Mugho pine; white pine; red cedar; Sawara cypress, var. *squarrosa*, var. *squarrosa sulphurea*, var.

FIG. 1.—Injury to the root system of Servian spruce by larvae of the strawberry root weevil.

plumosa aurea; Irish juniper; Swedish juniper; spiny Greek juniper; Pfitzer juniper; Savin juniper; Canada hemlock; Japanese yew; Oriental arbor vitae; American arbor vitae, var. *Rosenthalii*, var. *Douglasii pyramidalis*, var. *Douglasii spiralis*, var. *vervaeneana*, var. *umbraculifera*, var. *aurea*, var. *Siberica*, var. *elegantissima*, var. *compacta*, var. *globosa*.

INJURY.—Injury has been most noticeable and serious on hemlock, Servian spruce, and the following varieties of American arbor vitae: *compacta*, *globosa*, *Douglasii spiralis*, *umbraculifera*, *pyramidalis* and *elegantissima*. Generally speaking, the damage caused by the strawberry root weevil to conifers can be divided into two types, namely, root injury by the larvae and foliage or stem injury by the adults, figs. 1 and 2, respectively.

On hemlock and arbor vitae, upon which most of the work here reported was done, there is a decided difference in the injury caused by this pest. In the case of hemlock, feeding by the larvae on the roots is quite important. The adults also feed upon the leaves, but according to our observations this particular type of injury on hemlock by the adults is not apparently of a serious nature and is usually limited to small crescent or irregularly shaped areas. Girdling of the branches by the adults has not been of particular importance on hemlock. In contrast to the damage caused to hemlock, injury to arbor vitae may be most noticeable and serious on the parts of the plant above ground as a result of the feeding of the adult weevils. Most of this injury occurs in the top half or third of the tree and is detected by the presence of dead terminals (especially on small transplant stock, where heavy infestations prevail) or of dead and dying tips of the lateral branches. The weevils may either devour the tips of the new growth or girdle the bark in the same general area. If the twig is not entirely girdled the branch may callous over, in which case a definite

FIG. 2.—Foliage injury to American arbor vitae by adults of the strawberry root weevil.

swelling or gall-like object develops on the stem. Injury to the foliage is most evident during the summer or early fall months and frequently necessitates special or additional pruning practices by the nurseryman in order to remove the dead

portions of the plants before they are considered in condition to sell. Except in cases of heavy infestations the feeding of the larvae upon the root system of arbor vitae does not appear to affect the vigor of the plant very seriously.

Table 1.—Seasonal history of the strawberry root weevil during 1932 and 1936.

DATE	LARVAE		PUPAE		ADULTS	
	Number	Per Cent	Number	Per Cent	Number	Per Cent
May 20, 1932	458	100	0	0	0	0
May 26, 1932	426	95	25	6	0	0
May 30, 1932	107	70	47	31	0	0
June 7, 1932	105	22	365	77	5	1
June 10, 1932	188	18	812	77	61	6
June 15, 1932	41	14	208	73	38	13
June 22, 1932	2	1	11	5	211	94
May 22, 1936	140	100	0	0	0	0
May 28, 1936	60	78	17	22	0	0
June 3, 1936	42	47	48	53	0	0
June 11, 1936	25	10	158	63	69	27
June 18, 1936	6	4	61	38	94	58
June 24, 1936	0	0	12	3	422	97
June 30, 1936	0	0	2	2	117	98

SEASONAL HISTORY.—There may be considerable variation in the development of the various stages of the strawberry root weevil during different years. A knowledge of the seasonal history and habits of the insect are important from the standpoint of control, for the reason that it is essential to poison the weevils during the preoviposition period in order to prevent the establishment of a succeeding generation.

A study of table 1 will show, for example, that 18 per cent of the insects were still in the larval stage on June 10, 1932, and 10 per cent on June 11, 1936; also on the same dates and years, 77 per cent and 63 per cent, respectively, were still in the pupal stage, and 6 per cent and 27 per cent, respectively, had transformed to adults. Data of similar nature are also shown in table 2 for the years 1932 to 1936, inclusive, at dates indicated. In 1932, pupation and transformation to adults began at a slower rate than in 1936, but after a certain date proceeded faster.

The data given in tables 1 and 2 refer particularly to the proportion of larvae, pupae and adults as determined by digging up the trees and examining the soil carefully for the various stages, but the percentages indicated do not take into consideration the adults which had already emerged from their cells. For example, the following records were obtained on June 28, 1935. Of the various stages found, 67 per cent of the total were adults, and, of these, 53 per cent had emerged from their cells and reached the surface of the soil, while 47 per cent were still below the surface (not yet emerged).

Field studies in western New York from 1931 to 1936 indicate that the strawberry root weevil overwinters primarily in the larval stage, a few as prepupae and a very small percentage as adults. The adults seek winter quarters under stones, debris, etc., usually beneath the tree. According to our observations the percentage of adults which normally enters hibernation in western New York is relatively small, but in plantings that are heavily infested it is not difficult to find goodly numbers of the weevils which successfully survive the winter. Under such conditions, overwintering adults complicate the control program, or at least may necessi-

Table 2.—Variation in seasonal history of *Brachyrhinus ovatus* during different years at approximately the same date.

YEAR	DATE	PER CENT LARVAE	PER CENT PUPAE	PER CENT ADULTS
1932	June 15	14	73	13
1933	June 15	10	12	78
1934	June 16	13	50	37
1935	June 13	26	73	1
1936	June 18	4	38	58

tate an additional treatment early in the spring to prevent egg laying and reinfestation by these weevils. Adults, to some extent at least, are present in the field during the entire year but are most numerous and active from about the middle or latter part of June until early August. As will be noted in table 3, there

Table 3.—Normal mortality of the strawberry root weevil in the nursery planting in relation to hibernation.

Date	Per Cent of Weevils	
	Alive	Dead
Aug. 1, 1932	70	30
Aug. 8, 1932	70	30
Aug. 15, 1932	55	45
Aug. 23, 1932	54	46
Aug. 29, 1932	41	59
Sept. 6, 1932	14	86

was a very definite increase in weevil mortality beginning about the middle of August, and by early September approximately 90 per cent of the weevils were dead.

emerge for several days thereafter. The earliest emergence of recently transformed weevils in our observations was June 7, 1931, just about the time that the earliest varieties of strawberries were beginning to ripen. Weevils continue to emerge during the month of June and a few as late as the first week in July. The preoviposition period is difficult to determine under field conditions but dissections of weevils which emerged on June 2 1933, did not contain eggs when examined on June 21. During 1931, however, weevils which transformed from the pupal stage on June 13 and were kept in confinement without food or water began ovipositing on June 25, just 12 days after reaching the adult stage. It is quite likely that eggs are not laid in numbers until some time in July, although this has not been verified by egg counts under field conditions. On the other hand, overwintering weevils have been observed to lay eggs on June 3 (1933). Weevils which emerged from pupae during June (1932) deposited eggs as late as August 25. Eggs

Table 4.—Results of various soil treatments during 1931 for control of larvae of the strawberry root weevil on hemlock in nursery plantings.

Treatment	Number Applications	Dates Applied	Average Number Insects per Tree	
			Fall of 1931	Spring of 1932
Lead arsenate, 500 pounds per acre	1	May 28	132	147
Lead arsenate, 1,000 pounds per acre	1	May 28	76	127
Lead arsenate, 1,000 pounds per acre	2	May 28 and July 9	109	120
Lead arsenate, 1,000 pounds per acre, and Naphtalene flakes, 1,000 pounds per acre	2	May 28 July 9 and August 12	113	97
Naphthalene flakes, 1,000 pounds per acre	1	June 2	101	122
Naphthalene flakes, 1,000 pounds per acre	2	June 2 and July 9	120	116
Check, no treatment	—	—	135	—

The overwintering adults become active during the first warm days in the spring. They have been observed to move about under trees and to feed by May 15, before pupation of overwintering larvae occurs. During favorable weather, however, they may become active at a much earlier date. As indicated in table 1, recently transformed adults begin to appear in the soil about the first week in June, but of course they may not actually

laid on August 17 hatched on August 25 (1932). It is reasonable to assume, however, that temperature and other factors affect the preoviposition, oviposition and incubation periods. Because of this, the length of these periods may vary during different seasons, depending on prevailing conditions. For purposes of control, however, repeated experiments have demonstrated that if the bait is applied when approximately 75 per cent of the adults

have emerged the infestation can be greatly reduced.

The larvae spend the winter in the soil at depths varying from 6 to 14 inches. Early in the spring they begin to work upwards, again feeding on the roots, so that by the time pupation occurs the majority of the insects are within one to two inches of the surface and usually quite near the center of the root system. Pupation usually begins about the last week in May and emergence of the weevils extends over a period of four to five weeks. Pupae have been found in the soil under hemlock trees as late as July 1 (1936). On a given date there may be a noticeable difference in the percentage of larvae, pupae and adults in a planting which displays variations in topography, type of soil and drainage. For instance, on June 9, 1933, the following conditions prevailed in a nursery planting at points quite close together: *low, wet ground*, 79 per cent larvae, 21 per cent pupae and 0 per cent adults; *medium-high ground*, 19 per cent larvae, 33 per cent pupae and 48 per cent adults; *high, well-drained soil*, 100 per cent adults.

CONTROL.—During the past half century or longer, various workers in the United States and Canada have conducted experiments on the control of this insect as a pest of strawberries. It has also been investigated to some extent as a nursery pest. Many different methods have received consideration, including such practices as flooding, barriers, soil fumigation, trapping, cultural practices. More recently, however, applications of poison baits have come into common use and have proved relatively satisfactory in combating this pest in strawberry plantings.

Since 1931 the writer has been studying the life history and control of the strawberry root weevil as a pest of evergreens in commercial nursery plantings. Studies on control have included the following: Soil fumigation with carbon bisulphide, paradichlorobenzene and naphthalene, the incorporation of lead arsenate and naphthalene into the soil for control of the larvae; the use of dusts, sprays and poison baits for control of the adults. The lead arsenate and naphthalene were applied between the rows with a horse drawn Planet Jr. fertilizer distributor which was equipped with cultivator teeth for working the material into the soil. By this method the insecticides were uniformly distributed throughout the space between the rows and at least part of the material was placed within six inches of the trunks of the trees.

As may be observed in table 4, none of the soil treatments showed any appreciable reduction in the number of insects present. In this connection it is interesting to note that, with but one exception, 75 per cent or more of the insects had reached either the pupal or adult stage at the time the records were taken in the spring of 1932. This would indicate that the larvae were not seriously affected by the soil treatments which were applied the previous season. The numbers of insects indicated in column 4 of table 4 refer to living larvae counted on or after September 15, 1931, while those in column 5, for the spring of 1932, are records of living larvae, pupae and adults, respectively, of the same generation of weevils.

SUMMARY OF CONTROL MEASURES.—The various types of baits tested from 1932 to 1936 included bran-molasses, bran-oil, raisins-shorts, bran-sawdust-molasses and sawdust-molasses in which lead arsenate, calcium arsenate or sodium fluosilicate was used as a poisoning agent. The bran-molasses mixture most commonly used consisted of the following: bran 100 pounds, molasses 2 gallons, water 8 gallons, poison 5 pounds.

In the oil-bait mixture, 2 gallons of lubricating oil to 100 pounds of bran were used in place of the molasses and water for wetting the bran and poison. The raisins-shorts sodium fluosilicate bait was composed of 50 pounds of raisins, 50 pounds of shorts and 5 pounds of sodium fluosilicate. The sawdust-bran mixture consisted of 50 pounds of sawdust, 50 pounds of bran, 2 gallons of molasses, 8 gallons of water and 5 pounds of sodium fluosilicate.

The control obtained with these various treatments is given in table 5. These baits were used for the control of the weevils on both arbor vitae and hemlock with varying results, depending to a large extent upon the ingredients in the mixture, time of application and weather conditions after treatment.

On the whole, the bran-molasses and raisins-shorts baits containing 5 per cent of sodium fluosilicate have proved the

most effective treatments. Calcium arsenate and lead arsenate when used in the bran-molasses mixture at the rate of 5 per cent have afforded very good control in some instances and only a fair degree of control at other times. Generally speaking, sodium fluosilicate has proved somewhat superior to either calcium arsenate particular treatment will prove practical on hemlock. However, a spray mixture containing 6 pounds of calcium arsenate with a spreader gave high kill of the weevils on arbor vitae and showed promise as a control measure. To avoid foliage injury, the safened or stabilized calcium arsenates now being offered by most of

Table 5.—Results of various field treatments for control of adults of the strawberry root weevil.

Treatment	Year	Date Applied	Date Counted	Per Cent Efficiency[1]
Baits				
Bran-molasses calcium arsenate 8%[2]	1934	July 2	July 6	93
Bran-molasses calcium arsenate 5%	1936	July 6	July 10	93
Bran-molasses lead arsenate 5%	1936	July 6	July 10	82
Bran-molasses sodium fluosilicate 5%	1936	July 6	July 10	97
Bran-molasses sodium fluosilicate 5%	1936	July 13	July 17	79
Bran-molasses sodium fluosilicate 5%	1936	July 20	July 23	91
Bran-oil calcium arsenate 6%	1935	June 28	July 5	70
Bran-oil calcium arsenate 5%	1936	July 6	July 11	68
Bran-oil lead arsenate 5%	1936	July 6	July 11	74
Bran-oil sodium fluosilicate 5%	1935	June 28	July 5	94
Bran-oil sodium fluosilicate 5%	1936	July 6	July 11	79
Raisins-shorts sodium fluosilicate 5%[3]	1936	July 6	July 10	82
Raisins-shorts sodium fluosilicate 5%	1936	July 13	July 16	93
Raisins-shorts sodium fluosilicate 5%	1936	July 20	July 23	99
Bran-sawdust-molasses sodium fluosilicate 5%	1936	July 13	July 17	61
Sawdust-molasses sodium fluosilicate 5%	1936	July 13	July 17	22
Spray				
Calcium arsenate, 6 lbs. to 100 gallons; "Ortho spreader," 1 lb.	1934	July 2	July 13	92

[1] Calculated by Abbot's formula $100(x-y)/x$ (JOUR. ECON. ENT. **18** (2): 265–267. April).
[2] Refers to the per cent poison in the bait.
[3] This is the type of bait now being used by Drs. A. B. Buchholz and C. E. Palm in the control of the alfalfa snout beetle, *Brachyrhinus ligustici* (L.), in northern New York. The results reported here were obtained with such a bait made on May 5, 1936, and stored in one-bushel baskets at a temperature of 35° F. until applied on July 6, 13 and 20.

or lead arsenate, although from experiments repeated for several years there is reason to believe that any one of these poisons will effect a high percentage of kill of the weevils if applied under optimum conditions.

A spray mixture consisting of 6 pounds of arsenate of lead and one-half pound of calcium caseinate in 100 gallons of water, applied July 2, 1931, on hemlock, showed an efficiency of only 22 per cent on July 14. This treatment also caused a definite shedding and yellowing of the needles. Owing to the possibility of foliage injury, there is some doubt as to whether this the large insecticide manufacturers are suggested. One particular nurseryman in 1936 applied some 15,000 gallons of spray mixture containing a safened calcium arsenate without apparent injury. By way of comparison, a bran-molasses calcium arsenate bait gave an efficiency of 93 per cent four days after treatment, whereas a calcium arsenate spray did not show 92 per cent efficiency until 11 days after it was applied. Field observations indicate, however, that during periods of wet weather the kill from sprays may be more rapid than that which accrues from bait.—11-8-37.

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Some Dipterous Insects Reared from Narcissus Bulbs

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The purpose of this paper is to record some of the species of Diptera that have been reared from narcissus bulbs. All of the flies discussed here, except the daffodil fly, were reared from decayed bulbs and are therefore considered of little or no economic importance. Since the work of Creager and Spruijt (1935), the lesser bulb flies (*Eumerus* spp.) may also be considered as scavengers. The writer has reported the three species of this genus, *tuberculatus* Rond., *strigatus* Fall. and *narcissi* Smith from Long Island, New York, in a former publication (1933).

The daffodil fly (*Merodon equestris* F.) is recognized internationally as a pest capable of inflicting great losses to the narcissus industry. Until the past year or two, however, this fly has not been considered as much of a menace under Eastern conditions. In some varieties, according to recent reports from some of the local growers, the infestation reaches from 1 to 5 per cent. This is a considerable increase over the infestation of former years. During the summer of 1931 the writer tested several sprays for the control of this and the lesser bulb flies. At that time the greatest difficulty was to get an infestation of the daffodil fly in the checks or untreated plots, and for that reason further field tests were postponed indefinitely.

In addition to the above-named Syrphidae, two other syrphids have been reared, *Eristalis tenax* L. and *Syritta pipens* L. The latter is by far the more abundant species encountered. Hodson (1931) has illustrated the various immature stages of this species so as to show its distinction from the lesser bulb flies.

Three species of Stratiomyiidae, *Sargus cuprarius* L., *Microchrysa polita* L. and *Ptecticus trivittatus* Say, have been reared from these bulbs but the first two species are only rarely encountered. *Sargus cuprarius* is a European species that has gained a wide distribution in America. *Ptecticus trivittatus* is quite often encountered in decayed narcissus bulbs.

Along with an undetermined species of *Psychoda* and an undetermined *Sciara*, several species of Drosophilidae have also been reared.

Most of the notes given in this paper pertain to the family Otitidae, generally known as the Ortalidae.*

DESCRIPTIONS OF SPECIES.—A short description is given for each species together with an illustration of the wing. The length of the line given with some of the illustrated wings represents 1 mm.

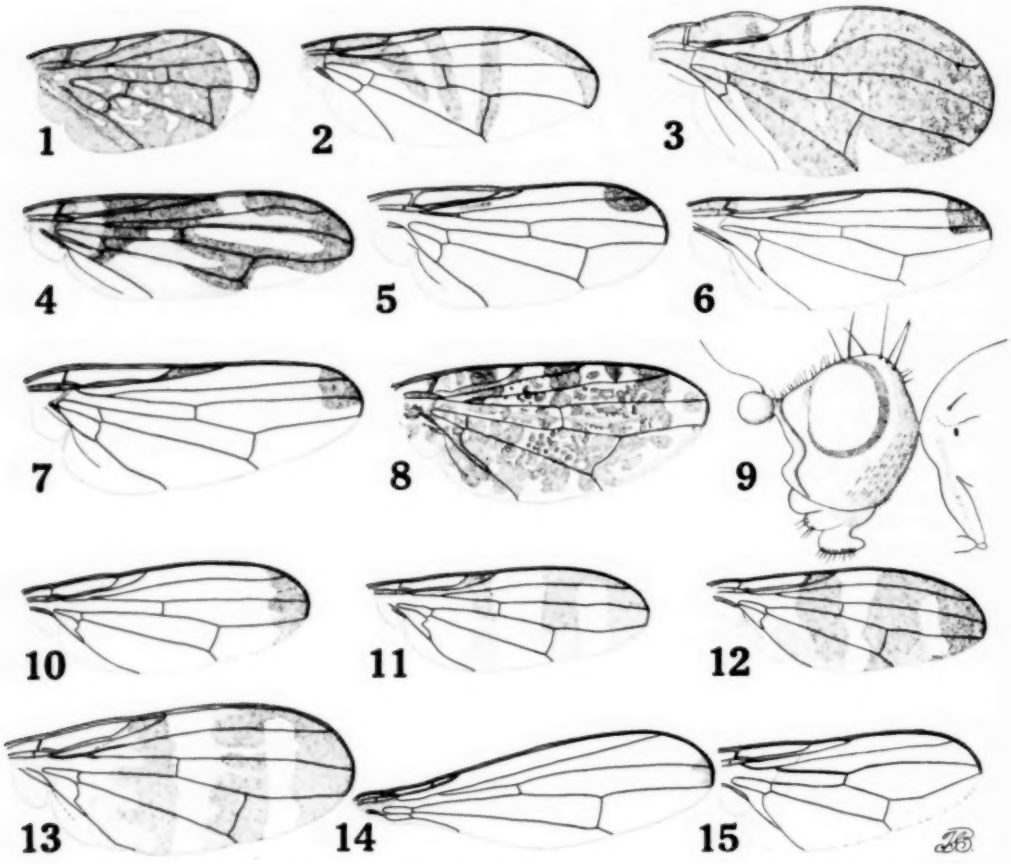
Amphicnephes pertusus Loew, fig. 1.—This is a very small, dark, metallic-green fly with pictured wings. Only three specimens have been reared from bulbs, but two others have been taken from a bulb refuse heap. It commonly occurs among the bracken ferns and has been observed to feed on the excretion of clusters of young leafhoppers. Only one species of the genus is known to occur in New York State.

Rivellia viridulans Rob. Desv., fig. 2.—This is a blackish-green species, with crossbands in the wing which resemble those in some species of *Rhagoletis*. A half-dozen specimens have been reared from the bulb refuse heap, but most of the large series of specimens on hand have been taken from the foliage of small locust trees or bushes adjoining bulb plantings. Tree hoppers are commonly found on these bushes, and this species, like *Amphicnephes pertusus*, feeds on the excreta. Several species of *Rivellia* occur in New York State, but only one other species of the genus has been taken in the vicinity of Babylon, N. Y.

Delphinia picta F., fig. 3.—This is a chestnut-brown species with a black abdomen. The wing pattern resembles that

* Aldrich (1932, p. 7) and Curran (1934, p. 273) have pointed out that the generic name *Ortalis*, on which the family name Ortalidae is based, is preoccupied in ornithology.

of some species of *Aciura* (Trypetidae). The species is commonly reared from narcissus bulbs and is at least as common as the lesser bulb flies at the bulb refuse heap. It is seldom taken, however, in the middle of large commercial plantings. It is found in wooded areas and has been taken from the trunks of locust trees while feeding on a gummy substance that had exuded from the injuries made by bark beetles and locust borers. Only one species has been described in this genus.



1. *Amphicnephes pertusus* Loew
2. *Rivellia viridulans* Rob. Desv.
3. *Delphinia picta* F.
4. *Idana marginata* Say
5. *Tetanops luridipennis* Loew
6. *Euxesta notata* Wied.
7. *Scioptera vibrans* L.
8. *Callopistromyia annulipes* Macq.
9. *Callopistromyia annulipes* Macq.
10. *Chaetopsis apicalis* John.
11. *Chaetopsis fulvifrons* Macq.
12. *Chaetopsis massyla* Walk.
13. *Chaetopsis aenea* Wied.
14. *Myrmecothea myrmecoides* Loew
15. *Chrysomyza demandata* F.

Idana marginata Say, fig. 4.—This is the largest species of this family occurring in the East. The ground color is black, but the transverse orange-yellow stripes of the thoracic dorsum and the crossbands of the abdomen give it a yellowish-black appearance. Only a half-dozen specimens have been reared from narcissus bulbs. Although this species has been considered as a rare Eastern fly, it is commonly found on the trunks of small locust trees in the vicinity of Babylon, N. Y. Only one species of this genus occurs in America.

Tetanops luridipennis Loew, fig. 5.—This is a dark gray species with numerous punctiform dots. The wings are of a cloudy, clay-yellow color with only a slight indication of a darker spot near the upper and outer end. Several specimens have been reared from narcissus bulbs, and the species is commonly found at the bulb refuse heap. Only one species of the

genus has been taken in the vicinity of Babylon, N. Y.

Euxesta notata Wied., fig. 6.—This is a bluish-black species. The abdomen of the female is yellow at the tip. The wings have a small, black dot in the middle of the costa, and a larger, triangular spot at the end of the wing. The base of the wing is gray. This fly is quite prevalent around narcissus bulb refuse heaps, and has been taken in the center of large narcissus plantings. It has been reared from bulbs many times, and during 1933 several thousand specimens emerged from bulbs being forced in the greenhouse. Only one species of the genus has been reported from New York State.

Seioptera vibrans L., fig. 7.—This is a shining black species with a red front. A black, triangular spot is found on the apex of the wing. The stigma is brown. The wing pattern somewhat resembles that of *Euxesta notata*, but this is a larger species with a red front and other plastic differences. This fly commonly breeds in narcissus bulbs and is often found at the bulb refuse heaps. Only one species of the genus is found in the vicinity of Babylon, N. Y.

Callopistromyia annulipes Macq., figs. 8 and 9.—This is a brownish-black fly, densely covered with whitish pollen. The head and body are covered with brownish spots. The wings are marked as seen in the figure.

Only one specimen has been reared from narcissus bulbs, but it is commonly taken on the trunks of locust trees. The habits of this species are very interesting in that both sexes have a peculiar way of holding their wings over the thorax, perpendicular to the body, so that the costal borders appear to be attached to each other. When disturbed, these flies allow their wings to assume the normal position. Only one species of the genus occurs in New York State.

Chaetopsis.—Although four species of this genus have been reared from narcissus bulbs, only one species, *C. fulvifrons* Macq., is commonly found on this host. The adults of all four species have been taken in numbers on beach grass at the edge of the tide water. The species of this genus are rather hard to identify, as there is considerable variation among the individuals. Curran (1928, pp. 79–80) has published a key to the species.

Chaetopsis apicalis John., fig. 10.—This is a bronze-green fly like the others of the genus. As may be seen from the figure there is only one band in the wing. Only one specimen has been reared from narcissus bulbs.

Chaetopsis fulvifrons Macq., fig. 11.—This species has three distinct bands crossing the wing which are evanescent posteriorly. As previously stated, this is the most common species of *Chaetopsis* in and around narcissus plantings, and it has been reared from bulbs many times. In April it is found throughout the plantings. The adults do not appear very conspicuous to the observer until he becomes familiar with their habits. They sit on the stems and foliage of narcissus plants and when approached move around to the opposite side of the plant. They have a peculiar habit of being able to run sidewise as fast as or faster than they can forward, and when released on a glass window they move both sidewise and forward. They are apparently very nervous and constantly flip their wings.

Chaetopsis massyla Walk., fig. 12.—The habits of this species are very similar to those of *fulvifrons*, but it is not at all common. Only one specimen has been reared from narcissus bulbs.

Chaetopsis aenea Wied., fig. 13.—This is a larger species than the others and is much darker than *fulvifrons* or *apicalis*. It is distinguished from other species by the number of cruciate-frontal bristles. Only one specimen has been reared from narcissus.

Myrmecothea myrmecoides Loew., fig. 14.—This species very much resembles an ant. The body is long and black. The wings are long and narrow, having a dark base and a brown spot on the apex. Only two specimens have been reared from narcissus and very few have been taken elsewhere. When found, it is usually on the trunk of a tree. Most specimens in the writer's collection have been taken with a test tube from the trunks of locust trees. It has been observed to feed on the sap exuding from wounds made by beetles in the bark of these trees. Only one species of the genus occurs in New York State.

Chrysomyza demandata F., fig. 15.—This species is distinguished from the others that breed in narcissus in the vicinity of Babylon by having hyaline, unpictured wings. The body is green. This

is a very common species and has been reared from narcissus bulbs on several occasions. It is found at the bulb refuse heaps quite commonly and is often taken in the center of commercial plantings. Only one species of the genus occurs in the vicinity of Babylon, N. Y., but the writer has taken a number of specimens of *Chrysomyza aenea* F. near the narcissus plantings at Willard, N. C.—8-28-37.

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A Survey of Insect Injury to Tobacco Grown for Flue Curing

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A field survey over an area embodying much of the acreage devoted to the culture of tobacco grown for flue curing in South Carolina, North Carolina and Virginia was conducted during August and September, 1935. The principal purpose of this survey was to determine the distribution and abundance of insect injury to tobacco leaves so that economic studies could be more intelligently planned. This insect damage to flue-cured tobacco not only reduces the yield per acre but lowers the grade.

Table 1.—A summary of the distribution and degree of insect injury to leaves of tobacco grown for flue curing in South Carolina, North Carolina and Virginia. August and September, 1935.

SECTION	NUMBER FIELDS	NUMBER PLANTS	NUMBER LEAVES	AVERAGE LEAVES PER PLANT	PER CENT OF LEAVES INJURED BY				PER CENT OF LEAVES UNINJURED
					Flea beetles	Horn-worms	Bud-worms	Grass-hoppers	
South Carolina	83	2,075	15,935	7.680	83.95	55.08	17.02	1.95	4.78
Southeastern North Carolina	39	975	8,347	8.561	89.16	58.46	11.54	2.04	4.32
Eastern North Carolina	73	1,825	10,472	5.738	98.61	35.91	9.79	2.94	0.42
Middle North Carolina	59	1,470	9,223	6.274	99.01	15.73	3.77	2.20	0.43
Western North Carolina	64	1,590	11,886	7.475	97.83	29.20	8.53	1.67	1.69
Virginia	67	1,670	12,012	7.193	99.26	22.84	4.19	5.69	0.46
Weighted averages	*385*	*9,605*	*67,875*	*7.066*	*94.04*	*36.93*	*9.68*	*2.76*	*2.15*

PROCEDURE.—The general location of fields was determined geographically in order to insure the accumulation of data which, when summarized, would be representative for the area covered. Data for each field were obtained by examining all the leaves on 25 plants and recording for

[1] Assisted in the field by E. W. Howe, F. S. Chamberlin and temporary assistants.

each leaf the presence or absence of insect injury. The 25 plants used for obtaining the information consisted of five samples of five competitive plants each. One sample was taken at random in the center of the field and the other four samples from the same relative positions in the four quarters of the field.

Insect feeding injury on each leaf was identified according to the insect which caused the damage. Where more than one type of insect injury was present on a leaf, a separate record was made for each. The survey being, of necessity, a qualitative one, no record was made as to the degree of insect injury to the leaves by any species, except that a leaf having less than five holes caused by feeding of flea beetles was recorded as "uninjured."

SUMMARY AND DISCUSSION OF RESULTS.—The survey included 385 fields that were well distributed over the portions of South Carolina, North Carolina and Virginia in which flue-cured tobacco was grown in 1935. Slightly more than half of the leaves had been harvested when the survey was made, and the data represent injury for an average of only the seven upper leaves of the plants. However, it seems likely that very similar results

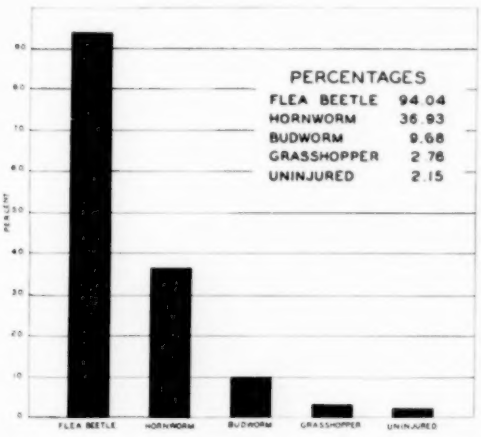

FIG. 1.—The average percentages of tobacco leaves that were injured by the more common insect pests on leaves of the growing plant. Averages taken from table 1.

might have been obtained had all leaves of the plants been present for examination, because general observations have shown that injury by flea beetles is more general and abundant on the leaves of the lower one-half of the plant, that injury by hornworms and budworms is confined principally to the upper two-thirds of the plant and that injury by grasshoppers is

FIG. 2.—Severe injury caused by hornworms in a neglected field of tobacco grown for flue curing near Petersburg, Va., during 1935.

usually well distributed over the entire plant.

Table 1 is a summary of the data from fields grouped by sections in the flue-cured area, and fig. 1 shows graphically the average percentages of insect-injured leaves for all fields examined. These data show that 94.04 per cent of all leaves examined were injured by flea beetles (*Epitrix* spp.).[2] The percentages of leaves showing injury by other common insects, in decreasing order, were those by the hornworms (*Protoparce* spp.),[3] the budworms (*Heliothis* spp.) and grasshoppers. Insect injury of lesser degree on the plants examined included that by the suckfly (*Dicyphus minimus* Uhl.), tree crickets (*Oecanthus* spp.) and the tobacco splitworm (*Phthorimaea operculella* Zell.).

Although the tobacco hornworms were found to have injured only 36.93 per cent of the total leaves examined during the survey, this species is considered to be a serious pest of tobacco grown for flue curing. Fig. 2 illustrates severe injury caused by hornworms in a neglected tobacco field.—8-16-37.

[2] Principally *Epitrix parvula* F.
[3] Principally *Protoparce sexta* Johan.

Notes on *Leperisinus aculeatus* (Say) and Its Parasites (*Coleoptera, Scolytidae*)

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About the middle of January, 1936, a felled ash tree containing numerous old galleries of *Leperisinus aculeatus* (Say) in the stem was found near Liberty Corner, N. J. This tree, which had a diameter, breast high, of seven inches, was probably cut the preceding spring. Sampling here and there revealed what appeared to be a heavy parasitization by a hymenopteron, later found to be *Coeloides scolytivorus* (Cress.). At this time these parasites were overwintering as larvae within cocoons in the ends of the larval galleries of the beetle. Sections from the trunk of the ash tree were cut and transferred to the laboratory for detailed study. Some of these were debarked immediately and several persons, some of whom were entomologists, estimated the parasitization of this bark beetle to run from 50 to 80 per cent.

PREVIOUS STUDIES.—The life history, habits and distribution of *Leperisinus aculeatus* have been treated by Knaus (1886), Felt (1905, pp. 288–289), Swaine (1918, p. 72) and Blackman (1922, pp. 62–63). The most extensive account is by Dr. Blackman. Very little, however, has been written about the parasites of this bark beetle. Fiske (1907, p. 24) records that *Bracon scolytivorus* Riley, identical with *Coeloides scolytivorus* (Cress.),[2] is parasitic upon this beetle, and, since the parasite completes its transformations and emerges many months before this particular host is ready to serve in that capacity, it becomes necessary for the parasite to seek another host that will be suitable. Under a discussion of parasites capable of continuing indefinitely on one host only, he cites the case of an apparently undescribed species of *Spathius*, a parasite of *Leperisinus* in ash. This parasite, according to Fiske (1907), "oviposits upon the [beetle] larvae in May and June, and its larvae, after development, spin cocoons in which all or a large proportion remain until May or June of the following season, when they emerge at the best possible time to attack the next succeeding brood of *Hylesinus* [*Leperisinus*]." Swaine (1918, p. 72) states that *L. aculeatus* is "often nearly exterminated in a limited locality by hymenopterous parasites and mites"; while Blackman (1922, p. 63) records having "observed several cases where the majority of the pupal cells of this species were occupied by cocoons of hymenopterous parasites," and "one case" where "over 90 per cent of the brood had been killed by such enemies."

THE PRESENT STUDY.—A number of the sections cut from the infested ash tree at Liberty Corner, N. J., were carried through the winter out of doors until late in the spring of 1936, at which time they were placed in rearing containers in an outdoor insectary. The following Hymenoptera were obtained from these mass rearings: 1,123 *Coeloides scolytivorus* (Cress.), which emerged from May 15 to June 18; 30 *Hypopteromalus* n. sp., emerging from May 16 to June 1; 22 *Stigmus americanus* Packard, which issued from May 16 to May 27; 3 *Spathius ? canadensis* Ashm., emerging early in June; and 1 *Eurytoma* n. sp., which issued on May 27. Since only *C. scolytivorus* was obtained in the large number of individual rearings made, it was the only species definitely determined to be parasitic on *L. aculeatus*. Since the material studied appeared to be practically a pure culture of *Leperisinus aculeatus*, however, it is likely that, except for *Stigmus americanus*, the other Hymenoptera are intimately associated with the beetle or with its primary parasite *C. scolytivorus*.

When the sections of wood were removed from the rearing containers, it was noted that the minute holes through which the parasites, *Coeloides scolytivorus*, had emerged were rather thickly interspersed with those of *Leperisinus acule-*

[1] Grateful acknowledgment is made to M. W. Blackman for helpful suggestions in the preparation of the manuscript, and to C. F. W. Muesebeck, A. B. Gahan and G. A. Sandhouse for identifying the Hymenoptera.

[2] C. F. W. Muesebeck points out that as Riley quoted from Cresson's manuscript, Cresson must be considered the author of the species.

atus. Moreover, both types of exit holes occurred throughout the bark of the logs because the bark beetle galleries practically encircled the trunk of this particular tree. Approximately $7\frac{1}{2}$ square feet of bark area from these sections were studied in detail. The total number of brood burrows counted in this sample was 311; so there was an average of about 41 per square foot of bark area. The mean length of the brood burrow was found to be 45 mm., ranging from 10 to 98 mm.

A count of the larval galleries in this sample was also made, but this included only those galleries made by larvae which were large enough to be readily seen. There were altogether 10,979 of these larval galleries, or an average of 35 galleries for each brood burrow, with a range of from 2 to 95 galleries. The total number of exit holes of *Leperisinus aculeatus*, which was determined by summing the entrance and exit holes and deducting the total number of brood burrows (one entrance hole per brood burrow), was 2,411. Parasite cocoons in the larval galleries of the beetle, on the other hand, totaled 1,139. An approximate measure of the percentage of parasitization of the full-grown bark beetle larvae can be derived by dividing the number of parasite cocoons (1,139) by the number of beetles that emerged (2,411) plus the number of parasite cocoons (1,139). Following this method, a parasitization of about 32 per cent is obtained.—8-16-37.

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Recent Experiments with Penetrating Oil Sprays for the Control of Bark Beetles*

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Search is constantly being made for better methods of controlling bark beetle depredations in western forests. Effort is being expended in improving the efficiency of present methods, in modifying them to eliminate hazardous practices and reduce costs and in developing new methods which may prove cheaper, safer and more efficient than those in current use. One of the recent developments in this work has been concerned with attempts to kill broods within or under the bark of infested trees by applying oil sprays to the outside of the bark. If successful, this method of treatment would eliminate the fire hazard which limits the use of the ordinary peeling-burning method of bark beetle control and, it was hoped, would reduce costs by avoiding the necessity for peeling the bark from infested trees. No previous studies of oil-spray methods for controlling bark beetles are known, although Craighead (1922) tested their effects in repelling insects and preventing injury to green logs.

The widespread outbreaks that occurred during 1931 in the pine forests of California, which resulted in the destruction of a billion and a quarter board feet of merchantable timber in that year alone, quickened the interest of the public in forest insect problems. The Standard Oil Company of California assigned N. N. Gay, of their research and development department, to determine if petroleum products could be used in the control of bark beetles, and asked the cooperation of the Bureau of Entomology and Plant Quarantine.

* A summary of experiments conducted by G. S. Hensill, J. M. Miller, J. E. Patterson, K. A. Salman and G. R. Struble, as a part of the research program at the Berkeley, Calif. Laboratory of the Division of Forest Insect Investigations.

Since 1931, members of the staff at the Berkeley, Calif., laboratory of the Division of Forest Insect Investigations have carried on a number of field and laboratory tests with oil for the control of bark beetles. Oil sprays have also been used under field conditions on two control-project areas. The results have shed considerable light on their effectiveness, use and adaptability under field conditions as they occur in California.

HOST TREES AND INSECT SPECIES—Most of the tests have been made on infested ponderosa pine trees. Broods of the western pine beetle, *Dendroctonus brevicomis* Lec., have been treated in 122 trees, flathead borers, *Melanophila californica* Van Dyke, have been treated in 15 trees and California five-spined engraver beetles, *Ips confusus* Lec., have been treated in 2 trees. Tests of the effectiveness of oil sprays in killing broods of the mountain pine beetle, *Dendroctonus monticolae* Hopk., have been made on 47 infested sugar pine and 12 lodgepole pine trees. The Jeffrey pine beetle, *Dendroctonus jeffreyi* Hopk., has been treated on 28 Jeffrey pines.

SPRAY MATERIALS.—Gay's preliminary work included tests of oils ranging from the heavy, viscous grades to the light, volatile types, and showed that the light distillates caused the highest mortality in bark beetle broods. Most of the subsequent tests have been made with oils of that type. Struble and Hensill tested various other grades of oil, crankcase drainings, and distillates of coal tar and wood tar, either alone or with other oils or substances. Stainless and black creosotes were tested. Naphthalene, orthodichlorobenzene, paradichlorobenzene and beta-naphthol, when dissolved or mixed with the oils, appeared to increase the toxicity of the sprays.

The best results were obtained with the following substances or mixtures:

(1) Diesel oil of 27° A.P.I. gravity with crude flake naphthalene at the rate of three-fourths pound per gallon. This spray costs about 10 cents per gallon. It should be mixed while warm and should be protected from low temperatures.

(2) Diesel oil (same grade as above) 2 parts, stainless creosote 1 part, lubricating oil, S.A.E. 30 viscosity, 1 part. The cost is about 30 cents per gallon.

(3) Diesel oil (same grade as above) with paradichlorobenzene at the rate of 45 grams per gallon. This gave good results in the 1934 tests.

The cost of the oil-naphthalene mixture is low enough to make its use practicable.

METHODS.—The methods used in all the field experiments were essentially the same. Trees were felled and limbed, and in the later experiments they were bucked and rolled so that the oil could be applied to all surfaces. The oil was sprayed on the bark until it began to run off, the heaviest applications being made in the crevices between the bark plates. Back pumps of the type used in suppressing forest fires were found to be satisfactory applicators. Pressure knapsack pumps holding from 3 to 5 gallons of oil were also used. Oil-resistant hose and gaskets were found to be necessary accessories. The type of spray nozzle that was used appeared to have little influence on the kill, but less time was consumed in applying the oil when the spray was coarse. However, it was discovered that too coarse a spray wastes oil.

RESULTS.—To be of practical value, oil sprays must give satisfactory control under the conditions of infestation, host and physical environment that occur in the field. The following results have been secured under those conditions.

Treatment of broods of the western pine beetle in ponderosa pine gave variable results. The average mortality ranged from 18 to 80.4 per cent for different series of experiments. In individual logs, the mortality ranged from 0 to 100 per cent. A mortality of about 60 to 70 per cent may be expected under the relatively favorable summer conditions. Treatment of broods of flathead borers in ponderosa pine was fairly successful, although there was great variation in its effectiveness. A complete kill of brood was reported in one of eleven tests. The results were unsatisfactory when counts were made in November, a month after treatment, but from counts made of samples from the same trees the following May an average mortality of 81.6 per cent was reported.

The character of the bark of host trees appears to affect the success of applications. The two tests against engraver beetle broods in the thin-barked tops of ponderosa pine gave mortalities of 94 and 95 per cent. Broods of the bole-infest-

ing western pine beetle and the flathead borer ordinarily are protected by a much thicker layer of bark than are those of the engraver beetle.

In sugar pine, which may have bark as much as 5 inches thick, the results were variable and, in general, unsatisfactory. Struble obtained average mortalities of but 44 and 46 per cent in two field tests, and Patterson observed that many of the treated trees contained nearly normal broods. Applications made to kill the mountain pine beetle broods in lodgepole pine appeared to be much more successful than those made against the same species in sugar pine. Struble and Hensill reported brood mortalities ranging from 61 to 100 per cent in 1934, while Salman obtained variable and unsatisfactory results in 1932, due chiefly to subsequent attacks in previously treated but uninfested phloem areas. The kill following treatment of Jeffrey pine beetle brood in Jeffrey pine was about the same as that obtained by treating mountain pine beetle brood in sugar pine.

All the experiments have shown that some mortality can be obtained by external applications of penetrating oil sprays or of mixtures of oils and other lethal substances. In many trees, entirely satisfactory results were obtained. All five species of insects against which the treatments were directed appear to be susceptible to the lethal action of the oils. The variable results indicate, however, that field conditions influence the effectiveness of the applications to a considerable degree.

LIMITING FACTORS.—Several factors are known to limit the effectiveness and use of oil sprays. The following may be important: brood resistance, conditions of infestation, time after treatment, temperature, moisture, coverage, host characteristics, transportation of materials and cost.

BROOD RESISTANCE.—Western pine beetle brood that had been removed from the bark for laboratory tests showed considerable variation in the resistance of individuals and brood stages to the action of oils and oil mixtures. Hensill found that some larvae lived for several days after immersion in the spray mixtures under standardized conditions and for stated periods of time, although others succumbed soon after the treatment. The fact that but a few treated larvae continued to develop, and that the mortality following immersion usually approached 100 per cent, indicates that unsatisfactory results in field tests were not due to poor insecticidal action of the sprays. Untreated larvae used as checks continued development, and their mortality was about 25 per cent. Fourth-instar larvae were more resistant than the younger larvae and were much more resistant than the pupal and adult stages.

Similar tests indicated that broods of the mountain pine beetle were much less resistant to the toxic action of oils than the same stages of western pine beetle broods.

The resistance of individuals or of brood stages may have been partially responsible for variations in the kill recorded for different samples that had been subjected to the same treatment under similar conditions. However, it seems more likely that the variation is primarily due to environmental factors.

CONDITIONS OF INFESTATION.—Much of the variability in effectiveness in the field appears to be due to the conditions associated with the development of broods. Spraying of uninfested portions of trees does not prevent subsequent infestation of the green phloem areas. Ventilation holes, which favor the penetration of the sprays, are constructed by all species except flathead borers. The western pine beetle is the only species in which the brood develops chiefly in the bark instead of between the wood and bark. From what is known of the penetration and spread of oil sprays in treated bark, broods of the species that develop in the phloem layer seem to have less protection against the action of the sprays.

Although the younger brood stages are less resistant to the action of the oil sprays, the moisture present in the phloem of the recently infested trees in which they occur retards the spread of the oil. Thus, the condition of the phloem counteracts the greater susceptibility of the younger stages and decreases the probability of successful control. The drying out of phloem and bark, which occurs gradually with the development of broods, favors the spread of oil and counteracts the greater resistance of the older larvae. The best results have been obtained in the field when fourth-instar

bark beetle larvae have been treated in dry bark.

TIME AFTER TREATMENT.—The death of brood that has come in contact with oil is not instantaneous. In the immersion tests, the percentage of kill varied with the period of immersion, the formula of insecticide used and the time since treatment. In laboratory tests, Miller found that, where the temperature was satisfactory, the mortality resulting from the treatments increased for a week or 10 days and then decreased. Under summer field conditions, from two to four weeks are required before the maximum kill is obtained. Struble found that the mortality of treated broods increased significantly during the winter, but the normal overwintering mortality may be responsible for a large part of that increase.

TEMPERATURE.—The treatment was not effective at temperatures below 50° F. However, exposure of sprayed bark to that temperature for 21 days, followed by exposure to 70° F. for a week, resulted in a satisfactory kill of brood.

In the field, oil penetration and effectiveness are increased if both bark and oil are warm at the time of application. The temperature of the bark of felled trees often exceeds 100° F., particularly if it is exposed to full sunlight on hot summer days. Such high temperature causes a considerable mortality over and above, and totally unrelated to, that caused by the oil. In the fall, winter and spring, low temperatures limit the effectiveness of the oil treatments.

MOISTURE.—The amount of moisture in the bark and phloem of infested trees is related to climatic conditions and to the development of bark beetle broods. During the winter and spring the high water content of infested bark helps to prevent the effective penetration of oil sprays. Satisfactory control has not been obtained in freshly infested trees, chiefly because of the high moisture content of the phloem. In many trees lengthy periods of attack or unequal rates of brood development in different parts of the tree cause variations in the water content of the phloem. As a result, the kill may be unsatisfactory in one part and satisfactory in another part of the same tree.

COVERAGE.—The amount of oil that can be applied in one treatment is more or less limited. Field applications ranged from 8 to 73 gallons per 1,000 square feet of bark surface, the average being about 20 gallons. Laboratory work showed that the heavier applications were more effective in killing brood. However, it is impossible to increase the amount applied in the field beyond a certain point without wasting materials, or without preparing the bark to increase its oil-absorbing capacity. Because of this attention has been directed toward determining the best methods of application.

If bark temperature and moisture are satisfactory, greater kill results if the entire area of infested bark is sprayed until the oil drips off. Application is then continued in the crevices until the maximum amount of oil has been applied. Bark that is hacked, scored or perforated by an axe or other implement can absorb slightly more oil than bark that has not been so treated. Removing the bark from the bole and spraying its inner surface results in a higher mortality. It is necessary that the logs be rolled and that spray be applied to all surfaces. Otherwise brood will continue to develop in the unsprayed bark, and successful emergence will occur.

HOST CHARACTERISTICS.—The bark of host trees differs in density, hardness, absorptive power and thickness. This is true even of trees of the same species, and in trees of different species the bark characteristics vary markedly. With the exception of bark thickness, however, none of these characters appears to have any appreciable influence on the effectiveness of the spray.

Hensill determined that there is very little direct penetration of the oil through the bark plates. Effective penetration occurs chiefly through cracks, crevices and breaks in the bark, or through areas where the bark is thin. Entrance and ventilation holes constructed by the bark beetles are of great importance in conducting the oil to the inner bark surface. Once the oil has reached the phloem, its spread along the brood galleries is facilitated by the frass that is packed in them. Many of the failures to obtain satisfactory kill in experimental tests may be traced to the fact that the oil did not penetrate to the phloem in amounts sufficient to reach most of the brood.

In ponderosa pine, satisfactory kill seldom was obtained in bark more than 1 inch thick. In general, unsatisfactory kill

of mountain pine beetle brood resulted from treatment of thick-barked sugar pines, but when the bark was shaved down until it was about one-half inch thick the treatments were more effective. Usually satisfactory kill resulted when well-developed mountain pine beetle brood was treated in thin-barked lodgepole pine trees.

TRANSPORTATION OF MATERIALS.—The transportation of oil and equipment to infested trees is often difficult and expensive. The use of wheeled vehicles of any considerable capacity is prevented by the nature of the terrain. The most practical method is to establish central supply depots along roads, and to take the oil to the trees by pack trains. The load of each animal of the pack trains is limited to about 20 gallons.

A man cannot easily work with more than 5 gallons of oil on his back. The usual amount needed for a tree is about 10 gallons, although as much as 68 gallons have been used in treating a single large sugar pine.

An oil transportation system can be set up that will meet the requirements of small experimental projects. However, transportation costs are high, and on large control projects the problem of placing the proper supplies of oil where and when they are needed has not yet been solved.

COSTS.—One of the objectives of the oil treatment was to reduce the costs of control work, particularly those associated with the peeling of infested trees. Another objective was to eliminate the fire hazard that is associated with the burning of infested bark. The average cost of the peeling and burning method, under a wide range of conditions, has been about $3.00 per thousand board feet. Costs are available for but one project in which the oil treatment was used. A total of 142 trees having a volume of 741,540 board feet were sprayed, and 1,176 gallons of oil were used in spraying 67,177 square feet of bark surface. Costs on that project were $3.39 per thousand board feet. It is apparent that there has been no reduction in costs by this method. In addition, the results have been less certain than those obtained by burning. It is, however, a method that can be used during periods of great fire hazard.

CONCLUSIONS.—It has been determined that satisfactory mortality of bark beetle broods within or under the bark of infested ponderosa, Jeffrey, sugar and lodgepole pine trees may result from external applications of penetrating oil sprays. The best control has been obtained with a light distillate type of oil in which crude flake naphthalene has been dissolved at the rate of three-quarters of a pound per gallon of oil. Brood resistance, infestation conditions, temperature, moisture and thickness of bark cause great variation in the brood mortality resulting from the use of the oil spray. In addition, the difficulties concerned with the transportation of supplies in the forested areas of California and the high cost of the treatment as compared with the peeling-burning treatment limit its use and adaptability.

Experimental results do not yet justify the general replacement of the peeling-burning method of bark beetle control by the oil-spray method. It may, however, be used to supplement other methods during the season of great fire hazard. The use of oil sprays appears to be of value in recreational areas or in commercial timber when infestation conditions or use requirements make it necessary to control forest insects during the summer.

The fact that satisfactory results can be obtained by external applications of contact sprays makes further study of the method desirable. Exact studies of the manner in which environmental factors limit the effectiveness of the sprays should be undertaken. Studies of new materials or combinations of materials, and new methods of application should be made in an effort to increase the effectiveness of the sprays and to reduce the costs of application.—8-25-37.

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Inoculation of Young Cicada Nymphs with Spores of Green Muscardine Disease*

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More than half a century ago, Leidy (1851) discovered a fungus disease occurring on the adults of the periodical cicada, *Magicicada septendecim* (L.). Peck (1879) first studied the disease and reported the causal organism under the name *Massospora cicadina* Pk. It is still uncertain as to the stage in which the cicada is attacked by this parasite.

This was the only known fungus disease of the periodical cicada until the discovery in 1936 of the green muscardine disease, caused by *Metarrhizium anisopliae* (Metsch.) Sorokin. In contrast to *Massospora cicadina*, this parasite, as reported by Katsura & Johnson (1937), attacks the mature nymphs very readily while it seems less effective upon adults. The present paper deals with the inoculation tests on newly hatched nymphs of the periodical cicada as carried out in the summer of 1936.

Fig. 1.—The green muscardine disease on cicada nymph. Spores of *Metarrhizium anisopliae* from the fatty tissue around the first and second nerve ganglia in the thorax of a mature nymph of *Magicicada septendecim* (×500).

Procedure.—Late in July, 1936, a large number of peach twigs bearing the eggs of the periodical cicada were furnished by Mr. L. O. Gillette from Arlington County, Va., where no fungus infection had been known. Leaves were removed, and the bark of the egg-bearing twigs was carefully disinfected with mercuric chloride, 1 to 1,000 solution, before being taken in a disinfected inoculation chamber.

The treated twigs were suspended in a row with their lower ends about eight inches above the table. Under these twigs, Petri dishes were placed so as to catch the nymphs that would hatch out of the eggs above. Five different plates of Petri dishes were arranged. Plate 1 contained slightly moistened soil mixed with five loops of spores of *Metarrhizium anisopliae*. Plate 2 (control) contained slightly moistened soil without fungus spores. Plate 3 contained sterile, moist filter paper upon which were dusted three loops of spores. Plate 4 (control) contained sterile, moist filter paper without spores. Plate 5 contained slightly moistened soil in which was placed a dead mature nymph killed by a previous inoculation of the fungus on July 25, 1936, fig. 1.

Results.—The eggs began to hatch on October 3. The young nymphs as they appeared dropped on to the soils and filter papers below. About 60 individuals were collected in each dish. Similar tests were arranged each day until October 8, when the material became all used up.

All the nymphs that were trapped in the spore-bearing dishes soon became contaminated and died in 15 to 24 hours, except those in plate 5 which survived somewhat longer. Those of the control plots lived normally from 4 to 15 days. White, cottony mycelium began to appear rather plentifully on the tiny bodies of the nymphs in 4 to 5 days after inoculation. The inoculation was far more deadly to the new born nymphs than to the 17 year nymphs from which the fungus was originally isolated into pure cultures on potato dextrose, nutrient beef agar and sterile rice kernel media.—8-27-37.

* Communicated by Ernest N. Cory.

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SCIENTIFIC NOTES

A New Chrysanthemum Pest, *Vanduzea segmentata* (Fowler)

In August, 1937, the tree hopper, *Vanduzea segmentata* (Fowler), was found breeding for the first time in large numbers on terminal shoots of commercial plantings of chrysanthemums at Opelousas, La. In September a few adults were found in a commercial planting at Alexandria, La. This hopper was originally described in 1895 from Mexico and recorded heretofore only from Texas and Arizona, with nothing known of its food habits. It was found to have made its first appearance at Opelousas during August of 1936. Since that time it has spread and increased rapidly. It breeds on the eggplant but shows a decided preference for the chrysanthemum and must be regarded as a serious new pest of that crop. Some chrysanthemum varieties, such as "Rose Perfection," "Mrs. Turner," "Pink Chieftain" and "Silver Sheen," seem to be preferred to others.

A sulfated fatty alcohol (*Orcus* W.A. Paste), used at the rate of 1 ounce per gallon of water, has given excellent results against this insect and plant lice with little indication of any serious burning on very tender varieties when applied in late afternoon.—9-16-37.

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Postfumigation Effects on the Cigarette Beetle in Tobacco Bales

A review of the literature on fumigation shows that most investigators have made it a practice to remove, at the end of a stated period of exposure, the test lots of insects from the commodity treated. In atmospheric fumigation these periods of exposure are in most cases from 24 to 48 hours and for fumigation in partial vacuum the range is from 2½ to 4 hours. It is well known that, in large quantities of fumigated material, an enormous quantity of the majority of gases is taken up by "sorption" and retained for varying periods of time, depending upon the temperature, the relative humidity and some other factors. It is clearly indicated in the literature that investigators have not given the postfumigation effects of this adsorbed and absorbed gas sufficient consideration in evaluating the results obtained under practical conditions of warehouse and factory. In order to obtain some information on postfumigation under the conditions of fumigation in vacuum, some experiments were carried out with hydrocyanic acid gas and the ethylene oxide-carbon dioxide mixture in the fumigation of baled tobaccoes.

HYDROCYANIC ACID GAS.—In the experiments with hydrocyanic acid gas, dosages of 4.3 and 5 pounds per 1,000 cubic feet were used with an exposure of 4 hours. Imported cigarette tobacco in bales, each bale weighing about 140 pounds, was used in all experiments. The vacuum chamber contained a volume of 1,165 cubic feet and in each experiment a total of about 17,640 pounds of tobacco was fumigated. The temperatures of the tobacco at the start of the experiments ranged from 59° to 62° F. Table 1 gives a summary of 13 experiments on the postfumigation effects of hydrocyanic acid gas on tobacco, as shown by test lots of well-grown larvae of the cigarette beetle (*Lasioderma serricorne* F.).

In all, 125 well-grown larvae of the cigarette beetle were used in each experiment and the same number for the controls. The chamber, loaded with tobacco, was fumigated for 4 hours in the usual manner, after which the tobacco was "air washed" twice and then removed to the warehouse. The absolute pressure in the experiments ranged from 0.16 to 0.38 inch, depending upon the barometric pressure on the date of fumigation.

ETHYLENE OXIDE-CARBON DIOXIDE MIXTURE.—The vacuum tank and accumulator used in these tests had a total volume of 1,193 cubic feet. Bales of cigar filler tobacco, each 29 by 24 by 23 inches and weighing about 158 pounds, were fumigated. In all, 93 bales of tobacco were used in each experiment and these completely filled the tank. The temperature of the tobacco ranged from 83° to 89° F. and the exposure was 4 hours in all experiments. A dosage of 58.7 pounds of the gas per 1,000 cubic

Table 1.—Postfumigation effects of hydrocyanic acid gas on cigarette beetle larvae infesting tobacco in bales.

Number of Experiments	Period of Exposure	Average Per Cent Kill at Designated Inches Depth in Tobacco				
		1¼	3¼	5¼	7¼	9¼
7	24 hours postfumigation	98.3	88.6	73.7	69.7	69.7
Controls (7)	Removed from tobacco after 4 hours exposure	86.3	66.9	65.1	57.1	58.3
3	48 hours postfumigation	100.0	96.0	97.3	92.0	82.7
Controls (3)	Removed from tobacco after 4 hours exposure	97.3	66.7	69.3	73.3	70.7
3	67 hours postfumigation	100.0	98.7	94.7	88.0	86.7
Controls (3)	Removed from tobacco after 4 hours exposure	84.0	66.7	50.7	56.0	58.7

Table 2.—Postfumigation effects of ethylene oxide-carbon dioxide mixture on cigarette beetle larvae infesting tobacco in bales.

Number of Experiments	Period of Exposure	Average Per Cent Kill at Designated Inches Depth in Tobacco				
		1½	3½	5½	7½	9½
4	24 hours postfumigation	97.0	83.3	90.2	88.7	84.6
Controls (4)	Removed from tobacco after 4 hours exposure	88.9	81.2	77.4	82.0	81.5
4	48 hours postfumigation	97.0	93.4	80.2	83.7	84.2
Controls (4)	Removed from tobacco after 4 hours exposure	86.3	77.4	55.9	73.9	69.7
4	72 hours postfumigation	100.0	94.0	92.9	89.0	89.0
Controls (4)	Removed from tobacco after 4 hours exposure	96.0	94.6	91.0	84.0	81.8

feet, or 4.9 pounds per 1,000 pounds of tobacco, was used. In all, 125 well-grown larvae of the cigarette beetle were used in all experiments and the same number in the controls. A summary of these experiments is given in table 2.

The absolute pressure in the vacuum chamber ranged from 0.86 to 1.00 inch, depending upon the barometric pressure on the dates the experiments were conducted.

DISCUSSION.—Although these data are not extensive, they clearly indicate that in order to obtain an accurate reading of the effects of the fumigant, test lots of cigarette beetle larvae fumigated with hydrocyanic acid gas and the ethylene oxide-carbon dioxide mixture should not be removed from bales of tobacco until about 72 hours after the exposure. The gas retained in the tobacco by "sorption" provides a postfumigation effect on the treated insects, and this factor should be considered in evaluating a fumigant under conditions of practical work. The postfumigation effects of hydrocyanic acid gas in tobacco bales were greater than those of the ethylene oxide-carbon dioxide mixture.—7-19-37.

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Pest Problems on Chrysanthemums Increased by the Practice of Shading

Established cultural practices have long been known to affect the insect pests that attack many crops. Pest problems are also known to be decreased or increased by changes in cultural methods. During 1935 and 1936, 23 florists' establishments were observed in which an increase in the damage by insects and mites occurred in greenhouses and aster cloth houses on chrysanthemums that were being subjected to a recently adopted cultural practice for advancing the flowering period and supplying flowers for the early market. This practice consists of covering the chrysanthemums daily, until the flowers show color, with black cloth to exclude the sunlight at 5 or 6 p.m. and keeping them covered until 7 or 8 a.m. The artificially shortened daylight period induces bud formation and the development of flowers as much as six weeks earlier than takes place under conditions of normal daylight (Post 1934). Stems of flowers on shaded chrysanthemums tend to be shorter than those on unshaded ones.

Free air circulation about the plant is prevented by the cloth covering, and the humidity becomes very high. Late in the afternoon and early in the morning the temperature becomes very high beneath the dark cloth and the foliage tends to become soft. The warm, humid conditions are favorable for the development of the cyclamen mite, *Tarsonemus pallidus* Banks, and during 1935 and 1936 this pest was observed to be much more serious on shaded chrysanthemums than on unshaded ones, both in greenhouses and out of doors in aster cloth shelters. The common red spider, *Tetranychus telarius* (L.), the thrips, *Thrips nigropilosus* Uzel, the Mexican mealybug, *Phenacoccus gossypii* Towns & Ckll., and the greenhouse leaf tyer, *Phlyctaenia rubigalis* (Guen.), were also causing more damage during 1935 and 1936 on shaded than on unshaded greenhouse grown chrysanthemums. It is probable, however, that these latter pests were more abundant on shaded plants because effective control measures were not applied during the period of shading rather than because of more favorable environmental conditions. Under such conditions a fungus leaf spot also becomes a serious problem and has been reported upon (Tilford 1937).

The problem of pest and disease control is a serious one under these cultural conditions. Tilford (1937) recommends the application of a fungicidal spray, before shading is started, to control the disease. In order to control satisfactorily such persistent pests as the cyclamen mite, thrips, red spider and mealybug, frequent and regular treatments are usually necessary throughout the growth period of the crop. Sprays applied during the short time that the plants are uncovered during the shading period often dry incompletely before the plants must be covered again, and such conditions induce the rapid development of the leaf spot disease and the loss of the foliage. Growers therefore refrain from applying any sprays during this period, and serious losses from one or more of the several pests result.

When control measures become necessary during this period of shading, fumigants or dusts, if effective, would be more suitable than sprays, because the latter would wet the foliage and increase the disease hazard. If it becomes necessary to make treatments at regular intervals for pest control, it is suggested that the plants be left uncovered on the evening they are to be fumigated or following the day on which they are sprayed. Such a program would probably be required no more often than every five days. By following such a practice the plants would be left to normal day length one day in five and, according to Post (1934, pp. 21–22), the earliness of bloom would be delayed only one week or even less. In order to bring the crop to maturity by a definite date, the grower should start shading it slightly earlier then he would than in the case of continuous shading.

At present the most successful growers plan to eliminate such pests as the cyclamen mite from their young stocks of chrysanthemums before planting in the beds. They attempt to reduce the other pests to a minimum by a scheduled series of treatments during the early growth period so that comparatively little damage results by unhampered activity of these pests during the shading period. The em-

ployment of dark cloth shading of chrysanthemums calls for increased skill on the part of the grower and good greenhouse equipment in order to produce a crop of high quality.—10-18-37.

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Effect of Insect Attack on the Rotenone Content of Stored Cubé Root

In 1931 a sample of cubé root received by the Division of Insecticide Investigations, U. S. Department of Agriculture, was found to be infested with insects. At the time of its receipt the sample consisted of 1,089 grams of whole root, tunneled by the insects, and 27 grams of powder, presumably formed by them. A number of live adult insects were taken from the sample and identified as a species of *Dinoderus.**

The powder was separated from the whole root, and from the latter several specimen pieces were set aside in a stoppered tube, the remainder being ground and analyzed for rotenone. Subsequently it was noted that the insects were continuing to attack the specimen sample of whole root. Recently this specimen sample was separated into 17 grams of powder and 52 grams of whole root. Specimens of adult insects were found, all dead, and were identified as *D. biforcolatus* Woll. The whole root was ground, and this and the two samples of powder (from the original sample and from the specimen sample) were analyzed for rotenone. The results for the four fractions of the root are as expressed in table 1.

Table 1.—Analysis for rotenone content of two samples of cubé root.

SAMPLE		PER CENT ROTENONE
Original Sample	Whole Root	3.3
	Powder Formed by Insects	1.4
Specimen Sample of Original Whole Root	Whole Root	4.1
	Powder Formed by Insects	2.3

It is seen that the portion of the root through which the insects tunneled, and which was thus reduced to powder by them, was lower in rotenone content than the remainder of the root. That there was no reduction in the total rotenone content of the root as a result of the insect attack was shown by the fact that the net rotenone content of the whole specimen sample, when the relative weights of whole root and powder are taken in account, was about the same as that of the original sample of whole root. Thus in a shipment of cubé root infested by these insects it might be expected that there would be no loss in the total rotenone content, provided none of the powdered material was lost.

* All identifications were made by the Division of Insect Identification of this Bureau.

Another sample of cubé root powder that had been formed as a result of insect attack was recently received. Insects found in this sample were identified as *Dinoderus biforcolatus*. The rotenone content of this powder, analyzed in this laboratory, was 1.0 per cent as compared with 4.2 per cent for the original whole root as reported by the sender.

Dinoderus minutus F. and *D. biforcolatus* Woll. have been mentioned by Miller (1935) among coleopterous pests of stored derris root in Malaya. Analyses of fractions of root attacked by coleopterous borers showed the frass or powder formed by the insects to be lower in rotenone content than that of the root from which it was derived.

In this laboratory a specimen sample of derris root set aside several years ago was also recently found to be infested with insects. These were identified as *Dinoderus biforcolatus*. The sample was a root from Sumatra of low rotenone content (0.5 per cent). Only a very small amount of the material had been powdered by the insects, and no attempt was made to analyze the two portions.—10-25-37.

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Life History and Control of *Phthia picta* Drury on Tomatoes

Phthia picta Drury (Hemiptera, Coreidae) has been a recognized pest of summer grown tomatoes in South Texas since 1933. It has been found in seven semi-arid counties southwest of San Antonio and in the lower Rio Grande Valley. This insect has been reported from Florida, California and Texas in the United States and from the West Indies, South America, Central America and Mexico. An excellent figure of the adult is given in professional paper number 192 of the U. S. Department of Agriculture. Brief mention of the injury to tomatoes and cotton and suggestions for control have been discussed in publications from Puerto Rico, Brazil and Argentina. The control methods recommended, namely, hand picking, clean culture and spraying with nicotine sulphate and soap, have not proved practical under conditions existing in Southwest Texas.

Damage to tomatoes is produced by adults and nymphs sucking the green-ripe and ripe fruits, causing them to turn dark green inside and to be very distasteful. The principal external indication of a fruit having been injured is the development of a yellowish spot about one-third of an inch in diameter. This injury may be confused with that caused by stink bugs. In Southwest Texas, damage is most severe to the small summer grown crop, but the main crop grown in the fall may be attacked. No injury to cotton by this insect scattering boll rot diseases has been observed in Texas.

Brief life-history and control tests were conducted during 1935 and 1936. The eggs are deposited in rows on the tomato stems, usually in the upper half of the plant. The average egg mass was 3.5 centimeters long and contained twenty-five eggs. The nymphs are gregarious during the first three instars, clustering on fruits unless disturbed and then run-

ning surprisingly fast. Those of the first two instars are usually quiet and seldom feed. Life-history studies were conducted in an insectary at Winter Haven, Tex., during 1935. The duration of the egg and nymphal periods is given in table 1.

Table 1.—Average developmental periods of *Phthia picta* and number of specimens observed in each.

STAGE	NUMBER OF SPECIMENS OBSERVED	AVERAGE DURATION IN DAYS[1]
Egg	275	9.0
First Instar	91	4.7
Second Instar	83	3.9
Third Instar	76	4.0
Fourth Instar	61	14.7
Fifth Instar	24	18.2
Total		54.5

It is probable that there are two and possibly three generations each summer. Adults have been observed feeding on tomatoes from early in June through October; however, the peak of the infestation was reached during August. It is not known how the winter is passed.

Preliminary control tests in which screen cages are used to confine the insects on the tomato plants were conducted during August and September, 1935. Both adults and nymphs were used in these tests, and each material was replicated six times or more. Table 2 gives the average control obtained with each dust.

Table 2.—Average per cent kill of nymphs and adults obtained in cage tests.

DUST	PER CENT KILL
Derris-sulphur, 0.75% rotenone	97
Derris-sulphur, 0.50% rotenone	85
Pyrethrum-sulphur, 0.125% pyrethrins	5
Nicotine sulphate-lime, 10% nicotine sulphate	5

A derris-sulphur mixture containing 0.75 per cent rotenone was used on a field scale during 1935 and again in 1936. Two applications of this dust at the rate of 25 pounds per acre were effective in keeping this insect under control.—12-1-37.

S. E. JONES, *Texas Agricultural Experiment Station, College Station.*

Horned Toads in Ant Control

Ants are responsible for keeping thousands of acres of western range land bare of vegetation, land which otherwise would support forage plants and livestock. Numerous species of lizards and small birds feed extensively upon ants in range areas, materially lessening their numbers, thus undoubtedly helping to limit the size of bare spaces around ant hills. The following is a summary of insect food contained in the stomachs of two species of horned toads examined, collected in Utah under range conditions.

Phrynosoma douglassii ornatissimum (Girard).—An examination of 51 stomachs of Girard's short-horned horned toad revealed the presence of 4 Neuroptera, 1 being a larva; 9 Hemiptera in 4 stomachs; 4 Homoptera, 2 being beet leafhoppers, *Eutettix tenellus* (Bak.); 57 Coleoptera in 20 stomachs, including 3 Elateridae adults and 1 wireworm; 11 Lepidoptera, 9 being caterpillars in 5 stomachs; 8 Diptera in 4 stomachs; 1,577 Hymenoptera in 46 stomachs, ants comprising 1,540 of the specimens in 42 stomachs; 5 spiders; and 151 parasitic roundworms in 6 stomachs. One horned toad under observations ingested 51 *Poganomyrmex occidentalis* in 15 minutes, 68 in 30 minutes, the total being 91 of these large red ants eaten by the end of one hour.

Phrynosoma platyrhinos Girard.—The stomachs of the 52 desert horned toads examined contained principally small insects, consisting of 8 Orthoptera, nearly all nymphal grasshoppers; 40 Hemiptera in 11 stomachs; 5 Homoptera in 5 stomachs; 83 Coleoptera in 33 stomachs; 41 Lepidoptera, 36 being caterpillars in 36 stomachs; 2 Diptera; 32 termites in 1 stomach; 2,143 Hymenoptera in 51 stomachs, of which 2,140 were ants in 49 stomachs; 1 spider; 1 centipede; and 518 parasitic roundworms in 16 stomachs. A nearly mature specimen of this lizard was observed to eat 64 ants, *Poganomyrmex occidentalis*, in 30 minutes, the number increasing to 89 taken as food at the end of one hour. Four medium-sized grasshopper nymphs had been eastern by this horned toad the day previous; so the lizard probably was not unusually hungry at the time it fed upon the ants.—10-10-37.

GEORGE F. KNOWLTON, *Utah Agricultural Experiment Station, Logan.*

Observations on Diptera Breeding in Tomatoes

The presence of dipterous larvae in commercially canned tomatoes has resulted in numerous seizures of the product on charges of adulteration under the Federal Food and Drugs Act. Recommendations for the use of canners in avoiding such contamination have been published recently by Ditman, Cory & Buddington (1936). These authors also present observations on the life history of *Drosophila melanogaster* Meig. and of *D. repleta* Woll.

Since the presence of the maggots in the canned product results from the use of infested raw stock, the studies reported herein were undertaken during the summer of 1934 to obtain information on the types of tomatoes infested under outdoor conditions and on the species of flies concerned.

The greater part of the fruit used in these studies was collected in the field or at canneries in Maryland by L. P. Ditman, of Maryland University, and the writer. The remainder was collected in the field at Arlington Farm, Arlington, Va. Each tomato was caged individually and placed in the insectary for rearing of possibly contained flies. The cages were open-end celluloid cylinders $3\frac{3}{4}$ inches in diameter and 10 inches long, with a narrow wooden strip 12 inches long tacked on one side. Each cage was set in a 4-inch flowerpot filled with sand, the tomato placed inside and the top covered with cheesecloth held in place with rubber bands. This type of cage has been described by Poos (1929).

The sand in the pot was kept moist, which prevented the fruit from drying out too rapidly and absorbed the excess juice from cracked or rotting specimens. (If the tomatoes are placed in a tight-bottomed cage this juice drowns any larvae that may be present.) The sand provides nearly normal conditions for soil-pupating forms. Since the fruit

was placed in these fly-tight containers immediately after it was collected in the field, any insects that appeared later in the cages must have been present on or in the fruit, either as eggs or larvae, at the time of collection.

The reared flies were determined by the late J. M. Aldrich, of the Division of Insects, U. S. National Museum, and by C. T. Greene and Alan Stone of the Division of Insect Identification, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.

At the time of collection the tomatoes were classified arbitrarily as to types. These types, with descriptions of the fruit in each, the U. S. grade and a list of the Diptera reared from each type are listed below.

TYPE 1. Firm, ripe, well colored. Peel unbroken. Collected in field and at canneries. U. S. No. 1. No flies reared.

TYPE 2. Firm, ripe, well colored, but with numerous growth cracks, which were, however, suberized and dry. Peel otherwise unbroken. Collected in field and at canneries. U. S. No. 1. No flies reared.

TYPE 3. Overripe, softening internal decay or tissue breaking down but peel unbroken. Collected in field and at canneries. Culls, some U. S. No. 2. No flies reared.

TYPE 4. Firm, ripe, well colored, but with fresh, undried growth cracks. No apparent mold or decay present. Collected at canneries. U. S. No. 1. Reared *Drosophila melanogaster* Meig.

TYPE 5. Firm, ripe, well colored, but cracked open in handling. Mold starting in cracks. Collected at canneries. U. S. No. 2 and culls. Reared *Drosophila melanogaster* Meig., *D. repleta* Woll. and *Muscina stabulans* Fall.

TYPE 6. Ripe, well colored, with numerous growth cracks which were partly suberized but in some of which mold and decay had entered, preventing them from entirely drying over. In some cases the decay had extended out from cracks into surrounding tissue. Collected in the field and at canneries. U. S. No. 2 and culls. Reared *Drosophila melanogaster* Meig., *D. repleta* Woll., *D. tripunctata* Loew, *Muscina stabulans* Fall. and *Fannia canicularis* L.

TYPE 7. Ripe, with deep cracks extending into seed cavities. Mold and decay well advanced in the cracks. Collected in the field. Culls. Reared *Drosophila melanogaster* Meig., *D. repleta* Woll., *Muscina stabulans* Fall., *Fannia canicularis* L., *Rhegmoclema atrata* (Say), *Neosciara tritici* (Coq.) and *N. coprophila* (Lint.).

TYPE 8. Overripe, softening or partly decayed, skin broken or fruit cracked open. Collected in the field. Culls. Reared *Drosophila melanogaster* Meig., *Muscina stabulans* Fall. and *Fannia canicularis* L.

TYPE 9. Almost to entirely a decaying mass. Collected in the field. Culls. Reared *Drosophila melanogaster* Meig., *D. repleta* Woll., *Muscina stabulans* Fall. *Fannia canicularis* L. and *Rhegmoclema atrata* (Say).

The first three types, from which no flies were reared, have one point in common, namely, none had open, undried wounds or cracks. In the case of *Drosophila melanogaster*, it has been observed that when a growth crack suberizes and becomes completely dry, any eggs that may have been laid on the tomatoes fail to hatch, or, if already hatched, the larvae either die or wander out over the surface of the fruit in search of another crack or wound. If none is found, these also die. In no case during these studies were larvae of this fly observed to burrow through healthy skin. It was observed that these maggots feed near the surface and do not work down into the interior of the fruit unless an injury has permitted a seed cavity to drain, thus making air available deep down in the tomato.

As is apparent above, the most commonly reared species were *Drosophila melanogaster*, *D. repleta*, and *Muscina stabulans*. *D. melanogaster* is much more likely to be found in any given tomato than the other two species and it occurs in much greater numbers. Furthermore, it was the only species reared from tomatoes where no apparent mold or decay was present in the growth cracks at the time of collection (type 4). These observations, coupled with the comparatively short life cycle of this species, make it the worst offender of the lot. Any of the other species listed, however, especially *D. repleta* and *M. stabulans*, is likely to be present in the canned product if proper precautionary measures have not been taken at the cannery.

The largest number of species, seven, were reared from tomatoes of type 7. There is no reason for believing, however, that all of the species listed, as well as others not encountered in these studies, might not be present in fruit of types 6, 8 and 9 if a large enough series of samples were taken.

In spite of the fact that *Drosophila melanogaster* was reared from tomatoes of type 4, fruit of this condition is probably not a source of trouble if canned without delay, and even if this is not done the cracks may suberize, resulting in the destruction of any eggs or death of any larvae that may be present. Tomatoes with growth cracks that have not dried over, owing to mold and decay, on down to those which are definitely rotten are evidently the source of maggots in the finished product.—10-29-37.

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Trichogramma evanescens Westwood, a Parasite of *Melissopus latiferreanus* Wlshn.

During recent years *Mellissopus latiferreanus* Wlshn. has become a serious pest of filberts in Oregon. For several years the Entomology Department of the Oregon Agricultural Experiment Station has had this filbert pest under observation, and during the past season intensive studies of life habits, control measures, etc. were undertaken. In our studies of the egg of the insect it was observed that 14.2 per cent of all eggs collected were parasitized. Adults of the parasite were reared and determined by Dr. P. H. Timberlake as *Trichogramma evanescens* Westwood (*T. minutum* Riley). Parasitized eggs were obtained from Monroe, Springfield and near Corvallis, Ore.—10-29-37.

B. G. THOMPSON, *Oregon Agricultural Experiment Station.*

Swarms of the Common Pentatomid, *Thyanta custator* (F), in Iowa

An immense swarm of the common pentatomid, *Thyanta custator* (F.) was reported in the February, 1937, issue of the JOURNAL OF ECONOMIC ENTOMOLOGY as having flown into Sioux Falls, S. D., on October 5, 1936, annoying that city by its numbers.

On October 8, 1937, almost exactly a year later, the same species made its appearance in Sioux City, Iowa, in enormous numbers. This species had not been unusually numerous in the vicinity of Sioux City during the season of 1937, and the source of the multitudes has not been ascertained. For several days these pentatomids were an unmitigated nuisance, swarming about the lights and entering stores and residences, while the odor from the thousands that were crushed on the walks by pedestrians was most unpleasant.—10-22-37.

C. N. AINSLIE, *U. S. Department of Agriculture, Bureau of Entomology.*

Scattering Grasshopper Bait from an Airplane

On numerous occasions it has been considered desirable to use airplanes for the spreading of poisoned bran mash for the control of grasshoppers, army worms and cutworms, and they have been used for this purpose in a few instances. It is the writer's opinion, however, that in most cases the results of spreading baits from airplanes have ranged from fairly satisfactory to entirely unsatisfactory.

During an outbreak of the army worm in wheat in May, 1937, a number of farmers in Tillman County, Okla., hired airplanes to scatter bran mash. The fliers of the planes first attempted to spread the bait from hoppers constructed for dusting fields with calcium arsenate, but soon discovered that such equipment was entirely unsatisfactory for scattering poison bran mash as it is commonly prepared. They next removed a door from a plane, and seated a man in the doorway with a sack of bran across his lap. The bait was dumped from the sack as evenly as possible while the pilot flew over the fields at heights of from 6 to 20 feet. Under such an arrangement the spreading was very uneven. At times, large amounts were dumped out while at short intervals almost none was released. Because of the great speed of the plane, even a few seconds in which no bran was thrown out resulted in long strips in the field receiving no poison. On the whole this method was not considered satisfactory, and the practice was soon discontinued. Although this is the only time the writer had seen such an attempt made, it is his opinion that this experience is more or less typical. In some cases special hoppers for handling bran mash have been constructed, some of which have been reported as satisfactory. This, however, entails the additional expense and time of constructing the hopper and thus far no hopper has been built that has been commonly used.

During the past two seasons, the writer has been experimenting with a number of grasshopper baits and it was thought that one of these might be successfully spread by an airplane equipped with a hopper, such as is used for dusting cotton fields with calcium arsenate. The formula for this bait is as follows:

Bran	100 pounds
White arsenic	5 pounds
Cheap grade of lubricating oil	2 gallons

The above mixture has been used to a considerable extent in a number of places, and in a few states it has been recommended by the state entomologist as being very desirable. Theoretically it will remain attractive to grasshoppers over a longer period of time than one in which water is used as a moistening agent because it does not dry out so rapidly. Preliminary work at this experiment station on a small scale in 1936 indicated that the above mentioned bait was considerably less effective than others tested which are more commonly used, but more complete work in 1937 indicated it has excellent killing qualities.

The consistency of the above formula was such that it appeared to be well adapted to spreading by an airplane as ordinarily equipped for dusting cotton. A preliminary test in which an airplane was used for this purpose was made near Stillwater, Okla., in August, 1937. The plane used was equipped for dusting cotton with calcium arsenate. Sixty pounds of the bait were placed in the hopper, which was opened as the plane flew across a road at different heights. The hopper was opened sufficiently wide so that enough bran might be scattered in the road to be seen readily. While it is not possible to gauge accurately the height at which the plane was flown, it was estimated the various heights the road was crossed were first, 12 to 15 feet; second, 25 to 30 feet; and, third, 45 to 50 feet. An examination of the road indicated that the bran was very evenly and satisfactorily spread. At 12 to 15 feet high, the swath covered was approximately 20 feet wide; at a height of 25 to 30 feet, about 48 feet were covered; and at a height of 45 to 50 feet the swath was approximately 90 feet wide. At the greatest height the bran was thinly spread at the edges of the area covered, but this disadvantage, of course, could easily be overcome by overlapping the strips slightly. A breeze of approximately three to four miles per hour was blowing, which resulted in a slight drift of the bait. The drift appeared uniform, however, and even with the plane at the greatest height this drift was not so strong that the bran would be carried entirely out of the field as so frequently occurs when dusting with calcium arsenate.

Forty pounds of bait were then placed in the hopper, and the plane flown at a height of approximately 20 feet, with the hopper partially opened all the way. There appeared to be a very even flow of bait until the hopper was practically empty, after which the flow rapidly thinned out until it ceased altogether. At the width of opening of the hopper used, two-tenths of a mile was flown before there was any decrease in the flow of bait.

These experiments, while exceedingly brief and preliminary, indicate rather definitely that it is entirely possible to spread such a bait evenly from an airplane equipped with the type of hopper commonly used for dusting calcium arsenate. C. W. Clifford, the pilot, and Al Guthrie, pilot and manager of the local airport, expressed their opinion that airplanes could be secured to scatter such a bait at a charge of not to exceed five cents per pound, and probably for less when large acreages are involved. Such a charge is distinctly higher than the cost of scattering by hand, but where time is an important factor, as is often the case, the use of airplanes for scattering this bait may be entirely practical.—11-1-37.

F. E. WHITEHEAD, *Oklahoma Agricultural and Mechanical College.*

JOURNAL OF ECONOMIC ENTOMOLOGY

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The New Journal Format

THIS ISSUE of the JOURNAL comes to the membership in a new page size and two-column format. The change has been made after careful consideration of all the various factors involved. It is neither the result of hasty judgment nor an enslavement to the idea that any and all changes are improvements or worth while.

A small exhibit of JOURNAL materials, including sample pages in two-column style, was displayed at the time of the Annual Association Meeting in Atlantic City in 1936. This display was made with the express purpose of acquainting the membership with the idea that the yearly publication in the JOURNAL of approximately 200 major manuscripts, some 60 smaller papers, besides numerous reviews, obituaries, notices and a varied assortment of illustrative materials, offered many printing problems. The two-column style and a somewhat larger page size was then advocated as a forward step, and actual specimen pages were on display.

Since the Atlantic City meeting there have been marked rises in printing costs due to increases paid for labor and materials, social security legislation and various other factors. The increased costs were sufficient to force again this past year an analysis of present JOURNAL printing and a possible future make-up to handle a steadily increasing amount of printed subject matter. No minor temporizing with combinations of types, which would still preserve readability, offered a solution of the real problems involved. This led to a consideration of JOURNAL printing from a wider angle, and the conclusion was reached that the two-column style, and its corollary, a somewhat larger page size, is the format now best adapted for the publication of JOURNAL materials.

The new two-column style with its shorter line has been demonstrated scientifically to permit faster reading, with less attendant eye strain, than the old page with its long line. One of its greatest advantages is the much increased flexibility allowed in the handling of motley collections and sizes of graphs, tabulations and illustrative materials. Although the page cost, because of increased size, is greater, this is more than offset by decreased alteration charges, reduction of expensive insets, or run-arounds, and increased word count per page. To many individuals, too, the openness of the page perspective is more pleasing than a tightly-packed, crowded page. The new JOURNAL page will not lessen total printing costs based upon past years, but it will result in lower costs than would the old style page under a new contract.

The new JOURNAL will seem strange to many subscribers, particularly those who have been closely associated with the magazine for many years. However, the Editor feels confident that, as time goes along, the advantages of the change will become apparent. The only argument seriously advanced to date against making the present change is one of objection against changing an established page size. To some this may seem a major disadvantage but to others it appears to be purely a personal matter and therefore not sufficient reason for all time to limit an adaptation of JOURNAL publication to modern printing conditions. The change is no reflection on a past size which has served the JOURNAL in good stead and was adopted when modern linotype machines were in their infancy.

In adopting the two-column style and larger page size the Association is not embarking upon any form of printing which is still in an experimental stage. Scientific and learned magazines in many fields have already adopted such printing. Furthermore, similar pages sizes are now used by many related biological publications which are received or consulted by entomologists.

Final action in adopting the new for-

mat was taken at the Association meeting at Indianapolis. The matter was thoroughly considered by the Advisory Committee of the JOURNAL, now the Publications Committee, and unanimously approved by the attending Committee members. This recommendation was then presented to the Association and adopted by vote at a well-attended business session.

The Editor and Publications Committee are confident that the change will rapidly win the approbation of the entire membership.

REVIEWS

Ascaris: The Biologist's Story of Life, by Richard Goldschmidt. 1937. Cloth, ix+390 pp., 160 figs. Prentice-Hall, Inc., New York. $3.25.

Written by a distinguished geneticist, formerly director of the Kaiser Wilhelm Institute of Biology in Berlin, now professor of Zoology at the University of California, this is an interesting book. The intestinal worm, Ascaris, is, as Dr. Goldschmidt admits, "nothing but a humorous pretext for gamboling pleasantly through the varied aspects of life." It leads the reader into the zoological fields of anatomy, physiology, embryology, genetics, adaptation and evolution. The emphasis is placed on function rather than on structure, and the reader gains an excellent general picture of the animal as a living machine. The illustrative material is drawn from many parts of the animal kingdom. Insects are introduced into almost every chapter. The accounts of the senses and sense organs of insects, and of the nutrition of social insects are especially interesting.

The language is simple and clear. Many homely similes are employed to make the descriptions of complex organs more easily understandable. Examples: muscles are engines and nerves the engineers; the cells of the body are not only the bricks of the building but also the brick makers and bricklayers; the eye is a camera; Pekingese dogs and Chinese gold fish are useless decorations allowed to exist in the parlor of Dame Nature but such forms could not exist in her work rooms where useless structures are eliminated by natural selection.

Experiences in Japan and in the Malay region add interest to the word pictures. Many of the excellent line drawings and diagrams are original. Others are taken from European sources. There is an index. —1-1-37.

—W. H. WELLHOUSE

Introduction to Economic Entomology, by W. J. Bearg. 72 pp., 1937. Russellville Printing Co., Russellville, Ark. Price $1.25, postpaid.

This book is a text-lecture outline from the author's notebook, printed on one side of sheets 8 by 10½ inches, two columns to the page. The reverse side of the pages are blank, presumably for class notes. The author has aimed to base much of the information "on studies made in Arkansas, and the text, therefore, is better adapted for students in the southern states than for students in some other regions." He believes, further, that the book is chiefly adapted to the needs of beginning students at the University of Arkansas.

The author has had in mind a study and lecture guide, giving essential facts about selected forms or groups and at the same time keeping the cost of the book to the student lower than that of commonly used textbooks. This has made necessary the omission of illustrations. The sections on Arachnida and the boll weevil, as one would expect from phases of the author's work, are particularly well done. The book may be ordered from the author at the University of Arkansas, Fayetteville.—11-17-37.

—ROGER C. SMITH

OBITUARIES

Leon Howard Worthley, 1877–1937

In the death of Leon Howard Worthley, which occurred at 3 a.m. Oct. 9, 1937, in Montclair, N. J., the United States Department of Agriculture lost a devoted public servant, and the science of applied entomology an able and indefatigable major executive.

Mr. Worthley was born July 13, 1877, at Skowhegan, Me., and was educated in the public schools of that place and at Saugus and Lynn, Mass. At the age of 20 he was engaged as a special scout in gypsy moth work by the Massachusetts State Board of Agriculture. In May, 1905, Mr. Worthley was engaged as Superintendent of Moth Control for the town of Saugus. At the end of that season he entered the employ of the State of Massachusetts and later was appointed Assistant State Superintendent of Moth Control. In this work he directed the activities of some 3,000 men and on Dec. 1, 1908, was promoted to the position of Acting Superintendent of that project, with which he remained until 1912.

During this period Mr. Worthley introduced many new and improved methods of procedure and developed mechanical apparatus that greatly increased the efficiency of moth spraying operations. Among these was the perfection of a nozzle that projects, at high velocity, a solid stream of insecticide, which becomes a misty spray, high in the tree tops. In order to attain this end there was required a readily portable power pump capable of maintaining a pressure much higher than any previously used in tree spraying work. It is related that when Mr. Worthley approached the engineering profes-

sion with specifications for such a pump, he was abruptly informed that his objective was impossible of attainment. Undaunted, he persisted and in the winter of 1909–10 was responsible for the development of the first power sprayer equipped with a bronze pump and four-cylinder engine. This had an increased efficiency of more than twice that of any previously existing apparatus and yet it was less than one-half the weight.

In 1911, Mr. Worthley was responsible for the development of the first power sprayer to be driven directly by the engine used to propel the auto truck transporting it. Owing to the great pressure developed by this new apparatus, it then became necessary to produce a hose coupling which possessed a full diameter waterway and which could be instantaneously detached. No existing coupling possessed these features, but Mr. Worthley found a way to have one designed and built; this is still in wide and successful use.

It was characteristic of the man that he refused to be deterred by difficulties but delighted in overcoming them. The excellence of his work under state auspices soon attracted the attention of the Federal Bureau of Entomology, and in January, 1912, he accepted appointment in that organization and was at once dispatched to Europe to study gypsy moth conditions and methods of control, and to collect parasites for shipment to this country. Upon return to the United States in the fall, Mr. Worthley was assigned a regional supervisory position in the gypsy moth control work and remained with the U. S. Department of Agriculture for the remainder of his life. This engagement signalled the beginning of a career in the regulatory and control phases of applied entomology unique in the annals of that science.

The year 1913 saw Mr. Worthley in field charge of all gypsy moth scouting work in New England and of Federal exterminative work in New Jersey, New York and Ohio. In the organization of this phase of activity he showed the highest degree of ingenuity and foresight. He was the originator of the arrow system of indicators for scouting crews whereby the supervisory official is enabled promptly to locate a crew, even in territory previously unknown to him, and thus to determine rapidly whether the work was being properly performed.

Leon Howard Worthley

In the summer of 1917 there appeared in the corn fields of Eastern Massachusetts an insect pest of foreign origin that caused great consternation among American leaders in applied entomology. This was the European corn borer and, during the following year, research revealed its potential powers of injury to crops and especially to corn. Soon it was found to have become established at several points in New York, Pennsylvania and Ontario, Canada, and there resulted a pressing demand for Federal regulatory and repressive action against the pest.

On April 1, 1919, Mr. Worthley was selected to take personal charge of these activities, with headquarters at Boston, Mass. He then began a series of major operations in insect control which continued for more than 15 years. These field control activities were of a magnitude without precedent in the history of economic entomology. In this totally new field of endeavor Mr. Worthley brought to bear the wide experience and those admirable attributes so well exhibited in the gypsy moth operations.

Although entirely lacking in formal knowledge of

engineering, he possessed a keen, innate appreciation of the mechanical requirements of his problems and was quick to sense their possibilities and to take advantage of them. After a season or two of experimental control with the corn borer, when it became evident that cultural control was the logical means of suppressing the insect on the farm, Mr. Worthley was first to see that existing agricultural implements were inadequate to cope with it. But when he approached the manufacturers of such implements with a request for cooperation he was repulsed and it was not until many years later, when the insect actually was entering the Corn Belt, that adequate cooperation from these organizations developed.

In the meantime, Mr. Worthley was untiring in his effort to advance this phase of the problem and he obtained the collaboration of the agricultural engineers of the United States Department of Agriculture, Ohio State University and Michigan State Experiment Station in devising such plows and other implements as he foresaw would be required to produce the cleanly plowed and gleaned fields necessary for corn borer control on the farm.

Although Federal quarantine enforcement under Mr. Worthley's direction succeeded in preventing the long distance dissemination of the corn borer through commerce in infested crops, during the period 1920 to 1926 inclusive, the insect had dispersed by flight into portions of 14 States, reaching from the Atlantic Coast westward to Indiana and Michigan. During this period, all of the Federal and some state quarantine and control operations progressed under Mr. Worthley's direction. During that period, too, many thousands of live corn borers, en route through commerce to distant points, had been intercepted and destroyed by his efficient highway inspection organization. In this interval he had also caused to be developed efficient machinery for rapidly and safely burning and otherwise treating areas that could not be cleaned up by hand methods or ordinary farm implements. This apparatus subsequently was used to immense advantage in a great suppression campaign.

By the close of the growing season of 1926, the excessive damage caused by the corn borer, both in Canada and in some of the lake states, aroused great fear for the future safety of the corn crop in the Corn Belt states. This resulted in an insistent demand upon Congress from officials of these and other states for $10,000,000 with which to undertake a major offense against the pests, with the idea of completely stopping its progressive dispersion. Although the Federal Government had already expended more than $3,000,000 for corn borer research and control, the appropriation requested was approved February 23, 1927.

The story of this unprecedented project is history and has been recorded elsewhere,[1] but in relation to this it should be pointed out that Mr. Worthley, who was chosen to direct this great field operation, entered upon it with full knowledge that the prospect of accomplishing the results expected by the sponsors of this huge appropriation were poor if not indeed hopeless.[2] That he faced this situation courageously is evidenced by the vast expenditures of energy, resourcefulness and tact with which he executed this project. Had it been humanly possible to halt the advance of the corn borer, it was apparent to all who witnessed these efforts that Mr. Worthley should have succeeded. However, invaluable lessons were learned and it would be a grave error if, in the history of applied entomology, this great effort were to be recorded as a failure.

Mr. Worthley continued to conduct corn borer control and quarantine operations until the end of 1932, when the Federal appropriation was withdrawn and control work was terminated.

In the meantime, the Japanese beetle had dispersed into territory already occupied by the corn borer, and a fusion of the administrations of these control activities resulted. Mr. Worthley was assigned these additional duties and in October, 1934, the certification and inspection activities under the gypsy moth quarantine were placed under his direction.

It would be difficult briefly to describe the extensiveness and intricacy of these operations but a faint illustration is the fact that, for the fiscal year ending June 30, 1936, Mr. Worthley's organization made nearly 75,000 certifications of commercial products under the gypsy moth and Japanese beetle quarantines and these did not include more than 22,000 certifications made in transit inspections under state quarantines on account of the European corn borer. All this work was exclusive of the highway inspection service for the Japanese beetle, in which as many as 2,500,000 vehicles were stopped and inspected annually and as many as 16,000 found to be transporting uninspected quarantined products.

In the summer of 1933, there was discovered, in the vicinity of New York City, an outbreak of a fatal fungous disease of the splendid elm tree, so widely grown for shade purposes throughout the northern United States. Mindful of the terrible havoc previously wreaked by a similar malady on the chestnut trees of the country, a campaign of eradication of this new pest, called the Dutch elm disease, was promptly initiated. Presently it was determined that certain bark beetles functioned as important vectors. This discovery resulted in the allocation of this campaign to the Federal Bureau of Entomology and Plant Quarantine. Shortly afterward, this new work was placed under the immediate direction of Mr. Worthley, to be carried on in addition to his many other duties.

With courage and genius characteristic of the man, he proceeded to loose a veritable whirlwind of attack against this menacing plant pest. In 1935, alert to every helpful mechanical innovation, he introduced the autogiro in order to detect, from the air, foci of infection of the disease, as indicated by wilting and dying elms, which otherwise might have escaped observation for years. Through these novel means more than 50,000 trees were sampled for the disease in that year. As many as 3,800 men were employed in scouting for the disease in a single season.

Enormous preventive operations were effected through the use of tools and apparatus suggested by Mr. Worthley, such as huge kerosene blowtorches for igniting piles of logs in wet weather and power chain saws and other saws, operated by mobile air compressor units, by means of which huge elm trees, that ordinarily required two or three days of hand labor, were completely disposed of in from six to eight hours.

[1] Report on the European corn borer campaign by the U. S. D. A. for the period March 14, 1927 to October 31, 1927, inclusive. Govt. Prtg. Office, Washington, D. C. 1928.

[2] Press release, January 18, 1928, U. S. D. A. Statement by Hon. Wm. T. Jardine, Secretary of Agriculture.

Throughout his years of public service, Mr. Worthley had closely followed the concentrations of his insect and plant pest foes, shifting repeatedly both his official headquarters and personal residence, sacrificing willingly both his private welfare and health, in order personally to direct the conflict at the scene of battle. What was to be the last shift of this kind occurred on April 6, 1936, when, in the interest of the work, headquarters were transferred from White Plains, N. Y., to Bloomfield, N. J., with his personal residence located in nearby Montclair.

On June 7 following, while stopping in Springfield, Mass., Mr. Worthley suffered a cerebral hemorrhage and fell heavily, but refused all entreaties to refrain thereafter from active direction of his work. On July 4 following, he sustained a second severe stroke and subsequently declined gradually until the end on Oct. 9. In the minds of his intimates there remains the conviction that he sacrificed his life in the interest of the Government service.

Mr. Worthley was socially inclined and held membership in many civic and scientific societies. He served as President of the Massachusetts Tree Warden's Association, 1917–1921, was a member of the Melrose, Mass., Chapter of A.F. & A.M., life member of the Massachusetts Horticultural Society and a member of the Cosmos Club of Washington, D. C. At the time of his death he was serving as Vice President of the Section of Plant Quarantine of the American Association of Economic Entomologists and took an active part in its proceedings.

In 1908, he was married to Harriette McMahon, who survives.

He was the author of many publications on the control of shade tree insects, the European corn borer, the Japanese beetle and the Dutch elm disease.

Beginning life's journey with but slight store of formal education, Leon Howard Worthley succeeded in demonstrating conclusively that he was a born executive and leader of men. His name is indelibly inscribed in the annals of entomological progress in North America.

Although the magnitude and character of Mr. Worthley's plant pest control operations necessitated the enforcement of rigid discipline among his hundreds of subordinates, this fact failed to render him by any means the callous or inconsiderate taskmaster. On the contrary, there was about the man a magnificent humanity, a keen and sympathetic understanding of human nature—its foibles and frailities—that endowed him with that rarest of talents, the ability to induce men of all kinds and conditions to bend with his will harmoniously to a common end. The crustiest of millionaires and the surliest of laborers seemed alike to him—as the clay under the hand of the potter.

No one will ever know the extent of Mr. Worthley's private charities and benefactions; he was generous beyond praise. In his lighter moments he was a genial and delightful companion.

For almost forty years he devoted his entire energies to the personal direction of a combat to preserve American forests and farm crops from destruction by insects and diseases, not from the comfort of a swivel chair but in the front-line trenches, and with a dynamic intensity, devotion and breadth of vision that evoked the wonder, admiration and applause of all beholders.

—W. R. WALTON, E. G. BREWER and LEE A. STRONG—12-3-37.

Robin John Tillyard 1881–1937

The death of this well known entomologist took place as the result of a motor car accident on Jan. 13, 1937. It occurred in Australia on the road between Canberra and Sydney: the car in which Tillyard was being driven skidded, and it resulted in his sustaining a fractured neck.

Tillyard was born on Jan. 13, 1881, his father being Mr. J. J. Tillyard of Norwich. He was educated at Dover College and Queens' College Cambridge; his principal training was in mathematics and he graduated in that subject in 1903.

Ill health prompted him soon after to seek a living in Australia, where he became mathematics master at Sydney Grammar School in 1904. His real interests, however, were in living creatures and he ultimately gave up mathematics. The opportunity came when he obtained a Government Studentship at Sydney University. A real turning point in his career was his election to the Macleay Fellowship of the Linnean Society of New South Wales, which he held from 1915 to 1920. During this period he published a long series of papers on dragonflies, which rapidly brought his name to the notice of the zoological world. A short time before the Great War, he became incapacitated as the result of a railway accident, which left him with a permanently altered and bent figure.

In 1909 he had married Miss Patricia Craske who rendered him incalculable service during his incapacity and throughout his life afterwards. While still an invalid, he graduated B.Sc. by research at Sydney University and later became a D.Sc. In 1920 he was appointed chief of the Biology Department of the Cawthron Institute, Nelson, New Zealand. The post proved highly congenial to him, and he remained there until 1928 when he became Commonwealth Entomologist for Australia. This important post he held for six years when ill health made it necessary for him to retire. After a time he recovered and came to enjoy life again. At this period he was very active and his interests were many and wide.

Tillyard's early researches on dragonflies culminated in his book on those insects which was published by the Cambridge University Press in 1917. It is still the best work of its kind. About this time he became interested in the wonderful Neuroptera of Australia and wrote extensively on these insects. The subject of venation, and its bearings upon the phylogeny of the Holometabola, had interested him for some time past. The outcome was his papers on the "Panorpoid Complex" wherein, by a close analysis, he claimed that under this title were to be grouped all the higher orders other than Coleoptera and Hymenoptera.

The subject of wing venation and phylogeny naturally led him to consider palaeontological evidence. The rich beds of Triassic and Permian age in Australia and of Permian date in Kansas provided him with a wealth of material. In a relatively short period he brought to light an amazingly interesting series of forms of great phylogenetic importance. His palaeontological work runs into about 60 papers and, of these, those on the Kansas fossils form an

especially notable series published in the *American Journal of Science*. The latest of these papers appeared in September, 1937—eight months after his death. Most of this kind of work involved interpretation of venational intricacies for which he had special ability, wide knowledge and a most retentive memory. Here and there some of his conclusions have led him astray but the great part of this work is of a high order. His interest in phylogeny also prompted him to study many of the lower orders of insects found in the Antipodes, especially the mayflies and stoneflies. He found time to write a large textbook, *The Insects of Australia and New Zealand* (1926), which has proved an invaluable aid to students and others in those lands. Few of his recent papers have attracted so much attention as his "Evolution of the Class Insecta" (1930) wherein, by an ingeniously thought out line of argument, he claimed that the class originated from few-segmented ancestors or Protaptera.

In the field of economic entomology his name is familiar in connection with the introduction of *Aphelinus mali* into New Zealand and the benefit which resulted from the control which this Chalcid exercised over the woolly aphis of apple. He was a whole-hearted believer in the all-sufficiency of biological control and initiated extensive schemes for the repression of noxious plants by such means in New Zealand. The results have not, however, so far confirmed his earlier expectations.

Tillyard was a man of restless energy and was "highly strung" temperamentally. In spite of weak physique and much ill health, his output of published work amounts to about 200 papers. For a number of years he was interested in physical phenomena and took every opportunity to investigate such manifestations. A short while before his death he played an active part in founding a new periodical, *The Australian National Review*, but lived to see only its first issue.

He leaves behind a vivid memory of an unusual personality in the minds of his friends. For a number of years he was a foreign member of the American Association of Economic Entomologists. He graduated Sc.D., Cambridge, England, in 1920 and became a Fellow of the Royal Society of London in 1925. He is survived by his widow and four daughters.

—A. D. IMMS, *Cambridge, England.*—11-27-37

CURRENT NOTES

CONFERENCE OF SOUTHERN ENTOMOLOGISTS AT BATON ROUGE

About 40 entomologists assembled at Baton Route, La., for the second annual fall conference of entomologists on November 12 and 13. Papers were presented on honeybees, toxicity tests, citrus sprays, rotenone dusts and sprays, velvetbean caterpillar, photography and other topics. Symposiums were held on the sweetpotato weevil and sugarcane insects.

R. C. Gaines served as general chairman; K. L. Cockerham served as chairman of the sweetpotato weevil symposium, and J. W. Ingram of the sugarcane insects symposium.—12-6-37.

—C. O. EDDY

MEETING OF ENTOMOLOGICAL SOCIETY OF ONTARIO

The seventy-fourth annual meeting of the Entomological Society of Ontario was held in the Theatre of the Royal Ontario Museum, Toronto, November 18 and 19, 1937.

The morning and afternoon sessions were almost entirely devoted to the reading and discussion of some 30 papers, which will ultimately be published in the sixty-eighth annual report of the Society for 1937.

The evening meeting took the form of a banquet held in the Walker House, at which the President, L. S. McLaine, Chief of the Division of Foreign Pests Suppression, Department of Agriculture, Ottawa, presided.

Dr. Hartzell of the Boyce Thompson Institute, and a few other prominent entomologists representing different institutions, made a few remarks, Dr. P. J. Parrott of the New York Agricultural Experiment Station was guest pseaker of the evening, giving an account of his recent trip through Africa. His address was illustrated by five reels of motion pictures, some in color. In a very enjoyable address, Dr. Parrott gave an interesting account of some of the entomological problems, the entomologists, the topography, and the wildlife of the country, which with his excellent pictures held the attention of his audience to the end.

The following officers were elected for 1937–38, the seventy-fifth year of the Society: President, Dr. Arthur Gibson, Dominion Entomologist, Entomological Branch, Department of Agriculture, Ottawa; Vice President, Georges Maheux, Department of Agriculture, Quebec, P.Q.; Secretary-Treasurer, R. H. Ozburn, Department of Entomology, Ontario Agricultural College, Guelph, Ont.; Editor, Dr. J. H. McDunnough, Entomological Branch, Ottawa; Associate Editor, H. G. Crawford, Entomological Branch, Ottawa; Assistant Editor, A. D. Baker, Entomological Branch, Ottawa. Directors are the President of the British Columbia Society, E. R. Buckell, Court House, Vernon, B. C.; the President of the Montreal Branch, H. A. U. Monro, Fumigation and Inspection Station, 785 Mill St., Montreal, Que.; Dr. Fred P. Ide, University of Toronto, Toronto, for Ontario; Prof. A. V. Mitchener, University of Manitoba, Winnipeg, Man., for Manitoba; H. L. Seamans, Entomological Laboratory, Lethbridge, Alta., for Alberta; F. C. Gilliatt, Entomological Laboratory, Annapolis Royal, N. S., for the Maritime Provinces. Auditors are Prof. L. Caesar, Department of Entomology, Ontario Agricultural College, Guelph, Ont., and G. G. Dustan, also of the Department of Entomology, Ontario Agricultural College, Guelph, Ont.

The next meeting of the Society is in June–July with the A.A.A.S. meeting at Ottawa, to which all members of the Entomological Society of Ontario and other entomological societies are cordially invited. The seventy-fifth annual meeting will be held in the fall, at Guelph.—12-29-37.

—R. H. OZBURN

INTERNATIONAL CONGRESS

A reduction in steamship rates has been secured for those attending the International Congress of Entomology in Berlin, August 15–20, 1938. This is available to members of the two national entomological societies and their immediate families. In addition to arrangements for those going directly to and from the Congress, a tour has been planned to include Ireland, England, Norway, Sweden, Denmark, Germany, Poland, Czechoslovakia, Hungary, Austria, Switzerland and France. Excellent opportunties will be offered for sightseeing, visiting museums and experiment stations, and for days at leisure in the mountains. The party will sail June 24 from Montreal and reach Quebec, returning, September 22.

—A. R. SHADLE and R. W. LEIBY, *Joint Committee of the Entomological Society of America and the American Association of Economic Entomologists*

HORTICULTURAL INSPECTION NOTES

REPORT OF THE NATIONAL PLANT BOARD

The thirteenth annual meeting of the National Plant Board was held in the Congress Hotel at Chicago, Ill., November 12 and 13, 1937. M. S. Yeomans, Acting Chairman of the Board, called the meeting to order at 10:00 a.m. Dr. J. F. Adams, former Chairman, explained that because of the resignation of Dr. Leiby, former Secretary-Treasurer, to take up other duties and then later his own resignation to enter commercial work, he had turned over the duties of both to M. S. Yeomans, Vice Chairman, until such time as the board could meet and reorganize.

All members of the board were in attendance, except A. C. Fleury of California. Those in attendance were J. F. Adams (Ex-Chairman) of Delaware, J. H. Montgomery of Florida, T. J. Headlee of New Jersey, J. I. Griner of Washington, R. H. Bell of Pennsylvania, C. J. Drake of Iowa, M. S. Yeomans of Georgia and E. L. Chambers of Wisconsin.

The minutes of the last meeting held at Chicago in connection with the second annual conference of state quarantine officials on Nov. 5 and 6, 1936, were read and approved.

The Treasurer's report, indicating that all dues were paid up-to-date and showing a balance on hand of $438.51, was read and accepted.

Ex-Chairman Adams then made a comprehensive report upon the activities of the Board under his direction since its last meeting including:

(1) Work of the Committee on the Establishment of Non-Plant Zone and Indemnity on Plant Pest Eradication.

(2) Progress being made toward addition to the principles of plant quarantine, the recommendations for non-political boundaries such as mountains, rivers, etc. The addition and printing of this principle awaits the action of two sectional boards, at which time it is planned to have it printed in a small booklet with the others.

(3) The azalea flower spot disease is of concern in the East along the Atlantic seaboard, and the board has been trying to interest the Bureau of Plant Industry in the control of this disease. It was reported that the board's plea is receiving little attention from that Bureau but the Bureau of Entomology and Plant Quarantine is on the job with an additional appropriation made available for investigational work and a progress report is to be made soon.

(4) The potato wart situation. The Bureau of Plant Industry, feeling that resistant varieties offered a control measure, has not supported attempts at eradication recommended by this board. Pennsylvania has demonstrated the feasibility of eradication with its own funds and is making good progress.

(5) Budget increases. Where board recommendations were made, they were successful, outstanding instances being the increase of the Japanese beetle control funds from $350,000 to $500,000 and the passage of the Pest Emergency Bill, much credit for which was attributed to Dr. Drake's efforts. The wisdom of such a fund was demonstrated by its usefulness in meeting several emergencies during the past summer.

(6) Committee on the Interstate Movement of Nursery Stock. Carrying out the instructions embodied in the resolution passed by the state nursery inspection officials, a committee was appointed consisting of J. H. Montgomery, Chairman, J. I. Griner, R. H. Bell and E. L. Chambers, representing the Southern, Western, Eastern and Central states respectively.

(7) Complying with the suggestions contained in the resolution passed by the state inspection officials on uniform state quarantines that each regional board appoint a committee to review the subject in the states comprised by said regional board, the following committee appointments were arranged: *Southern*—M. S. Yeomans, Clay Lyle, B. P. Livingston; *Western*—R. G. Richmond, E. Hutchings, Frank McKennon; *Eastern*—T. J. Headlee, A. B. Buchholz, C. E. Temple; *Central*—G. A. Dean, C. J. Drake, E. L. Chambers.

(8) Weed control. Following the recommendations of the board, a weed control committee was appointed, consisting of C. L. Corkins, Chairman, W. C. Muenacher and R. H. Porter. Because of refusal of support from two of the sectional boards for additional funds to finance the expense of this committee, it was necessary to abandon contact work in Washington before much progress had been made. The Bureau of Plant Industry did not see fit to support this bill. Consequently nothing much was accomplished, and the bill did not pass.

Lee A. Strong, Chief of the Bureau of Entomology and Plant Quarantine, who was invited to sit in with the Board, outlined how successfully and effectively the new emergency insect pest bill had met such problems as the army worm outbreak in the South and grasshopper control in the West, and how it had aided in taking immediate action in the control of the newly-discovered white-fringed beetle.

The meeting was adjourned at 1:00 p.m. to resume business at 1:30 when an open meeting was scheduled to permit representatives from nurserymen's associations, state quarantine officers and others who dropped in at the meeting on short notice to get first-hand facts concerning the announcement of the Bureau of Entomology and Plant Quarantine issued October 18 to recipients of special permits for importation of propagating material under regulation 14 of Quarantine 14.

In addition to the members of the Board, the fol-

lowing were in attendance: Lee A. Strong, Washington, D. C.; Walter J. Robinson, Olympia, Wash.; Leeman Anderson, Atlanta, Ga.; B. P. Livingston, Atlanta, Ga.; H. F. Seifert, Urbana, Ill.; J. Carl Dawson, Jefferson City, Mo.; Frank McKennon, Salem, Ore.; G. R. Hyslop, Corvallis, Ore.; Paul Stark, Louisiana, Mo.; Harold Welch, Shenandoah, Iowa.

The visitors were all given an opportunity to speak in behalf of this subject and the discussion brought out the fact that all were anxious to learn what such a proposal might do and each was definitely in favor of tightening up the requirements rather than loosening them up, and voiced their interest in the prevention of introduction of pests rather than any form of embargo. Some concern was expressed in letters written by nurserymen and read into the record as to result of unlimited introduction of certain types of nursery stock that might be produced more cheaply abroad to compete with higher priced labor production in this country, pointing out that large investments had been made by many importers to carry on the business.

Mr. Strong indicating that he would gladly answer any questions the group might have on the proposal, outlined what might be expected in the matter of revision. He pointed out as previously that he felt Quarantine 37 was illogical and that it should be changed. He reminded his hearers of his address last July before the American Association of Nurserymen, at which time he explained his stand very clearly.

He called particular attention to troubles with the special-permit situation, which he declared is entirely unfair, his contention being that if any plants or plant materials are dangerous because of pests or diseases, they should be kept out entirely; if plant materials are not affected, they should be admitted freely without restriction other than inspection at the port of entry. Plants with soil should not be admitted at all, he said.

With the resumption of the business session at 7:30 p.m., reports were received from the various regional boards. A motion was moved, seconded and passed that the National Plant Board reconsider its action with respect to noxious weed control taken at its last meeting and rule that it is not a function of this Board to control noxious weeds and that the committee appointed to support legislation on this subject be dismissed.

The meeting was again called to order by the chairman at 9:30 Saturday morning to continue the discussion on resolutions presented by the Western Plant Board. It was moved, seconded and passed that a resolution be drafted showing appreciation for the emergency appropriation requested by the Board at its last meeting and urging its continuance, pointing out the benefits, possibilities and savings derived. On this committee were appointed J. H. Montgomery and C. J. Drake. The resolution follows:

"WHEREAS, The Seventy-Fourth Congress provided for the use of and through the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, a fund of $2,000,000 for meeting emergencies involving the control and eradication of incipient outbreaks of major plant pests, and

"WHEREAS, By reason of this wise provision the Department of Agriculture has been enabled during the past year to effectively handle such emergency situations as the outbreak of grasshoppers in the Middle West, the white-fringed beetle in Florida and Alabama and also an outbreak of army worms in the South, and

"WHEREAS, Had not this emergency fund been available at the time when the emergencies arose there would, through lack of financial resources, have been delay in inaugurating the necessary control measures resulting in inestimable losses, and

"WHEREAS, The wisdom of Congress having thus been demonstrated, therefore,

"*Be it Resolved*, By the National Plant Board in meeting assembled at Chicago, Ill., on November 12 and 13, 1937, that the Secretary of Agriculture, the Bureau of the Budget and Congress be and hereby are urgently petitioned to continue to make available for the use of the Bureau sufficient funds for the purposes indicated, namely, to control, eradicate and prevent the spread of emergency outbreaks of major plant pests inimical to agriculture, and

"*Be it Further Resolved*, That in the opinion of this Board such provision should be in the sum of not less than $2,000,000, and

"*Be it Further Resolved*, That copies of this resolution be sent to the Secretary of Agriculture, the Director of the Budget, the Chairman of the Appropriations Committee of the House of Representatives and the Chairman of the same Committee of the United States Senate."

The nominating committee consisting of J. H. Montgomery, C. J. Drake and R. H. Bell recommended M. S. Yeomans for Chairman, T. J. Headlee for Vice Chairman and E. L. Chambers for Secretary and Treasurer, and they were duly elected by the Board.

The meeting was adjourned at 3:30 p.m. Saturday, November, 13.

—E. L. CHAMBERS, *Secretary-Treasurer*

REPORT OF THE EASTERN PLANT BOARD

The Eastern Plant Board met in Philadelphia on Nov. 17 with an attendance of 35, representing all the states of the Board except Maine and New Hampshire.

A program covering all the major quarantine problems in which the Eastern states are interested was presented by Federal and state workers. Particular mention should be made of the presentation of Mr. Hartman of the potato wart eradication program under way in Pennsylvania, which offers great promise.

The committee on standardization of inspection practices and uniformity in provisions of interstate quarantines reported only four quarantines. The committee was continued.

The principal action of general interest was the following recommendation:

The Eastern Plant Board commends the efforts of the Bureau of Entomology and Plant Quarantine toward eradication of the Japanese beetle in outlying infestations and recommends that every state in which isolated infestation points occur be urged to cooperate with the Federal Government in similar efforts whenever worth-while results may be indicated.

Special mention should be made of the address by Mr. Strong with regard to Quarantine 37; the work upon the white-fringed weevil, which could not have been prosecuted if an emergency fund had not been available; the increased needs of the port inspection service; and the value of the taxonomic unit to all quarantine work.

The following officers were selected: G. T. French, President; Ernest N. Cory, Secretary-Treasurer; H. L. McIntyre, H. B. Weiss and R. H. Allen, Executive Committee; R. H. Bell and T. J. Headlee, Representatives to National Plant Board.—1-7-38.

—ERNEST N. CORY, *Secretary-Treasurer*

REPORT OF THE CENTRAL PLANT BOARD

The Central Plant Board met at Kansas City, Mo., for the thirteenth annual meeting of the group, with ten of the member states officially represented.

The usual number of problems of long standing were presented for discussion and action. One of these that was discussed was the inspection of raspberries for the mosaic diseases, with the possibility of discontinuing the second inspection. Mr. Aamodt led the discussion with a report of the work in Minnesota. After a general round-table discussion of the effectiveness of the second inspection, with inspection records presented covering both sides of the question, it was decided to retain the two inspections on raspberries.

B. M. Gaddis of the Bureau of Entomology and Plant Quarantine was unable to be present but forwarded a paper on the "Phony Peach Disease." The paper brought out the fact that it has been possible to expand greatly the scope of the work with the grant of moneys from the Emergency Relief appropriations. The ground thus gained in the eradication of this disease must be held to protect the orchard owners against further losses.

Mr. Gaddis also stated that "recent investigations have failed to support the theory that the peach borer is the important carrier of the disease. It is now certain that further study is needed before it can be said any insect is of sufficient importance as a carrier of the disease that it should be included as a part of the quarantine requirements."

The following suggestion was submitted to the group: "Standardized revision of all phony peach quarantines to eliminate culling as a condition of the certification and to require the annual inspection and removal of all diseased trees from nursery environs prior to June 30, for movement of peach nursery stock in or through any part of an infected state."

Dr. L. E. Melchers of the Kansas State College talked on virus diseases and reviewed the high points in their study. The discussion was of a general nature and it is to be regretted that a complete copy of this talk was not furnished for publication in the minutes.

Dr. Melchers concluded his remarks with the following statement:

"The present control measures of a virus plant disease are unsatisfactory because of the time consumed, because of the costly measures necessary and because of their temporary nature. The greatest progress in the next fifteen years will be in the breeding of resistant strains of crops, unless new, unforeseen involved difficulties arise in the plant virus field, such as the 'mutation' or rapid increase of new and virulent strains of viruses. This new field offers considerable promise.

"Today we have come to look with concern upon any species of insect (especially in certain insect quarters) which is known not to exist in the United States as a potential danger of being a new vector unknown to science, for it may mean the establishment of a virus disease of a plant, now unheard of in this country."

The southern vegetable plant situation and its relation to the northern grower was discussed by Dr. R. W. Samson of Indiana. Following a very complete discussion of the diseases and insects affecting these plants and the lack of available information concerning their control, a committee of three was appointed to investigate this situation and make recommendations for future action.

A standing committee on uniform regulations suggested several changes in nursery inspection recommentations, which were adopted. These changes did not materially change the program as adopted the previous year.

Several resolutions were presented by the committee on resolutions and adopted, urging that the Congress of the United States continue its funds for several major projects and in some cases increase the amount previously appropriated.

The Central Plant Board for many years has been working toward uniformity of inspection regulations and quarantines among states, and consistent with this policy the Board asked the following resolution relating to the proposed inspection law in Colorado:

"WHEREAS, It has become a state and national policy to discourage the requirement of fees and bonds for the interstate shipment of nursery stock, and,

"WHEREAS, It is the consensus that the recognition and acceptance of state inspection certificates by other states is essential to the welfare of all growers of plants and the proper functioning and correlation of inspection services between states so as to permit free interstate movement of horticultural and agricultural products, and,

"WHEREAS, Dormant inspection of nursery stock does not detect virus diseases such as peach mosaic and many other plant diseases and insect pests, and

"WHEREAS, Destination inspection of nursery stock will often result in additional delay and damage from exposure as well as additional and unnecessary cost to the consumer or home growers, and

"WHEREAS, Plant inspection work is in the interest of all agriculture, both producers and consumers, and the cost of inspection should not be borne by any one group, and,

"WHEREAS, certain sections of Colorado House Bill No. 545 and Senate Bill No. 615 are diametrically opposed to present day trends relating to nursery inspection and quarantine work, and

"WHEREAS, the Central Plant Board desires to secure the cooperation of Colorado and all of the states in working toward uniform regulations, relating to plant inspection and plant quarantines, and desires to encourage the friendly relationship between states so that interstate shipments of agricultural products may move without being unnecessarily hampered, therefore,

"*Be It Resolved*, That the Central Plant Board at its regular annual meeting, March 3, 1937, at Kansas City, Mo., go on record as being strongly opposed to Colorado House Bill. No. 545 and Senate Bill No. 615 and that copies of this resolution be sent to the Governor, Director of the Department of Agriculture and the State Entomologist of Colorado."

—P. T. ULMAN, *Secretary*

REPORT OF THE SOUTHERN PLANT BOARD

A regular meeting of the Southern Plant Board was held at San Antonio, Tex., February 17, 1937, in

connection with a joint session of the Texas Entomological Society and the Cotton States Branch of the American Association of Economic Entomologists. This meeting adopted a resolution asking Congress to make an emergency revolving fund of $5,000,000 available to the Bureau of Entomology and Plant Quarantine. A committee to work for uniformity in state quarantines was appointed. Dr. J. H. Montgomery tendered his resignation as Secretary of the Southern Plant Board, having been appointed chairman of a committee of the National Plant Board to work for uniformity of quarantines. M. S. Yeomans was elected representative on the National Plant Board to fill the unexpired term of Dr. R. W. Leiby. The following officers were elected: Chairman, B. P. Livingston; Vice Chairman, G. M. Bentley; Secretary-Treasurer, Clay Lyle.

A special meeting of the Southern Plant Board was held at DeFuniak Springs, Fla., on July 26, 1937, with Professor G. M. Bentley as chairman, Mr. Livingston having previously resigned. The meeting was called for the purpose of discussing the situation caused by the presence of the white-fringed beetle, *Naupactus leucoloma* Boh, in a small area on the Alabama-Florida line and was attended by plant quarantine officials from eight states and by several representatives from the Bureau of Entomology and Plant Quarantine, including Lee A. Strong, Chief. The day was spent observing the insect under field conditions, reviewing the information which had been secured in regard to its life history, habits and control, and in a discussion of future plans for handling the situation. The next meeting of the Southern Plant Board was announced for February 2, 1938, in New Orleans.

—CLAY LYLE, *Secretary-Treasurer*

REPORT OF THE WESTERN PLANT BOARD

The nineteenth annual conference of the Western Plant Quarantine Board was held at Phoenix, Ariz., June 1-3, 1937. Most of the member states were represented and there were also representatives present from British Columbia, Canada and the Department of Agriculture of Mexico.

The usual report on pest control and quarantine conditions was presented by each of the attending representatives. A number of excellent papers were read, as follows:

"Progress in Peach Mosaic Disease Eradication," by B. M. Gaddis, In Charge, Division of Domestic Plant Quarantines, Bureau of Entomology and Plant Quarantine, Washington, D. C.

"Peach Mosaic Disease in Colorado," by Carrol W. Wade, Deputy Entomologist, Division of Agriculture, Denver, Colo.

"Foreign Plant Quarantine Enforcement," by E. R. Sasscer, In Charge, Division of Foreign Plant Quarantines, Bureau of Entomology and Plant Quarantine, Washington, D. C.

"Post Office Cooperation in Terminal Inspection and State Plant Quarantine Enforcement," by N. B. Wentzel, Superintendent, Division of Classifications, Post Office Department, Washington, D. C.

"The Tomato Pinworn," by J. C. Elmore, Assistant Entomologist, United States Bureau of Entomology and Plant Quarantine, Alhambra, Calif.

"Methyl Bromide as a Fumigant," by D. B. Mackie, Supervisor of Entomology, Department of Agriculture, Sacramento, Calif.

"Plant Quarantine and Control Work in the Bureau of Entomology and Plant Quarantine," by Avery S. Hoyt, Assistant Chief, Bureau of Entomology and Plant Quarantine, Washington, D. C.

"Results of Tests to Determine Survival of Adult Alfalfa Weevil in Baled Hay," by Dr. John C. Hamlin, Senior Entomologist, In Charge, Alfalfa Weevil Investigation, Salt Lake City, Utah.

All of these papers discussed subjects of immediate interest to all of the quarantine representatives present.

A number of special topics were submitted for committee consideration during the meeting. In addition to the usual general resolutions passed, special resolutions were passed

(a) commending the work of Dr. Hamlin and his associates in connection with their investigational work on regulatory entomology in relation to the hazard of alfalfa hay as a carrier of alfalfa weevil, and the Bureau of Entomology and Plant Quarantine was urged to secure funds for the completion of this valuable investigational work.

(b) pointing out the pest hazard from unrestricted aircraft entry from foreign countries and urging the Interdepartmental Committee on Aircraft to consider the immediate revocation of all existing permits authorizing inland airports as ports of entry, and recommending that airports of entry for foreign planes be approved only in the case of those airports located immediately on or adjacent to the United State border.

(c) commending the Mexican fruit fly eradication effort of the Bureau of Entomology and Plant Quarantine and requesting the Director of the Budget to consider the importance and need of sufficient funds to carry on this project adequately.

(d) pointing out the importance to agriculture in the United States of preventing the entry of foreign plant pests, and urging the Secretary of Agriculture and the Director of the Budget to consider the need of providing adequate funds to the Division of Foreign Plant Quarantine Enforcement and the Bureau of Entomology and Plant Quarantine to carry on the additional protective work arising from the increase in foreign commerce.

(e) commending H.R. 4009, a bill then before Congress calling for the appropriation of Federal funds for noxious weed control and eradication; urging the National Plant Board to make a study of the spread of noxious weeds through the medium of seed shipments for the purpose of recommending a solution of this problem; pointing out that postal regulations do not now permit the rejection of parcel post seed shipments by inspection officials because of the presence of weed seeds, and that impure field and flower seeds are a major cause of field infestations of noxious weeds, many such weeds acting as alternate hosts for crop infesting insects and diseases, and requesting the National Plant Board to approach the postal authorities with a view to obtaining such changes in the postal regulations as may be necessary to protect agriculture in that regard; urging the National Plant Board to take a leading part in an effort to stimulate weed control interest and to define the term "noxious weeds" and to draw up one or more lists of "noxious weeds" to act as a basis for further study.

The following officers were elected for the ensuing year: Roy G. Richmond of Colorado, Chairman; Frank McKennon of Oregon, Vice Chairman; A. C. Fleury of California, Secretary-Treasurer; J. I. Griner of Washington, Representative to the National Plant Board to replace W. H. Wicks of Idaho.

—A. C. FLEURY, *Secretary*

PROCEEDINGS OF THE FIFTIETH ANNUAL MEETING

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Hotel Lincoln, Indianapolis, Ind., December 27-31, 1937

The Fiftieth Annual Meeting was held in the Hotel Lincoln, Indianapolis, Ind., December 27 to 31, both dates inclusive. There was a total registration of 283.

In advance of the general and sectional meetings, the Codling Moth Conference and the Tobacco Insect Council met on Monday, December 27. The first meeting of the Executive Committee was also held on Monday. The Section of Apiculture and the Pea Aphid Conference were held simultaneously on Tuesday morning.

The general session began with the Presidential Address at noon on the 28th and continued through to one o'clock, December 31. A long list of interesting papers was presented. The Section of Extension met on the 28th, and the Section on Plant Quarantine and Inspection met on the 30th. The final business session was held the afternoon of December 31.

On the afternoon of the 28th a joint session with the Entomological Society of America, presided over by Dr. O. A. Johannsen, heard a most interesting symposium on the relation of insects and plant diseases.

The Entomologists Dinner, with an attendance of 236, was held on the evening of the 29th, with Professor P. J. Parrott giving the public address of the Entomological Society of America. His talk, "Loafing Through Africa," was followed by the showing of several reels of moving pictures of his trip. These he accompanied with running comment.

Considerable time was devoted during the course of the session to the discussion of the revised constitution. After several changes in the Committee report, a new constitution was adopted and ordered to become effective at the close of the meeting on December 31.

The place of meeting for 1938 was left to the Executive Committee with power to act.

COMMITTEES APPOINTED AT FIRST BUSINESS SESSION

December 28, 1937

COMMITTEE ON RESOLUTIONS:
Geo. M. List, *Chairman*, Franklin Sherman, Arthur Gibson.

COMMITTEE ON NOMINATIONS:
B. A. Porter, *Chairman*, C. O. Eddy, J. S. Houser.

COMMITTEE ON CONSTITUTION AND BY-LAWS:
A. F. Burgess, *Chairman*, W. E. Britton, Arthur Gibson, E. F. Phillips, C. L. Metcalf.

COMMITTEE ON COOPERATION WITH NATIONAL PEST CONTROL OPERATORS FOR 1937:
W. P. Flint, *Chairman*, J. G. Sanders, J. J. Davis, E. A. Back, Neely Turner.

COMMITTEE ON ARRANGEMENTS FOR INTERNATIONAL CONGRESS OF ENTOMOLOGY, BERLIN, AUGUST 18-20, 1938:
R. W. Leiby, A. R. Schadle.

TO REPRESENT THE ASSOCIATION ON DUTCH ELM DISEASE ADVISORY COUNCIL:
Roger B. Friend.

COMMITTEE ON RELATION OF ENTOMOLOGY TO CONSERVATION:
C. J. Drake, *Chairman*, T. H. Frison, R. D. Glasgow.

REPORT OF THE SECRETARY AND BUSINESS MANAGER

The total paid-up membership for the year as of December 23 is 1, 118, an increase of 313, representing 54 new members; the remainder of the increase is accounted for by reinstated members and members with dues brought up-to-date.

Although publication costs have increased, the JOURNAL account shows a balance of $4,843.27, an increase of $1,123.36 over the balance for 1936. The publication fund for Index V stands at $936.50. To this amount will be added fifty cents per member for 1938. Approximately one-half of the cost of the new Index will be paid in advance. The contract has just been let, and it is anticipated that Index V will be mailed about April.

The finances of the Association show a net increase of approximately $1,500, after $500 has been transferred to the Permanent Fund. The latter fund shows an increase of approximately $1,000. To this will be added $450.00 from the sale of called Federal Farm Loan Bonds.

There are 71 membership applications to be voted on at this meeting. Unfortunately the Association has lost by death 11 valued active members, as follows: A. J. Ackerman, P. W. Claassen, C. R. Crosby, V. L. Kellogg, L. C. Marston, Jr., F. S. Stickney, Frederick V. Theobald, R. J. Tillyard, W. M. Wheeler and L. H. Worthley. By resignations we

have lost 25 members, as follows: Thomas Armstrong, S. E. Crumb, Henry Fox, L. A. Frost, Arthur M. Gillespie, Cecil R. Gross, William R. Haden, Marvin M. High, C. Hargreaves, W. A. Johnson, K. L. Kessler, E. J. Kraus, D. F. Miller, L. J. Padget, K. L. Russell, Herbert Spangenberg, J. R. Spies, T. J. Talbert, R. L. Taylor, Allen J. Warren, G. E. Washburn, S. A. Watson, C. B. Williams James D. Winter and Floyd H. Wymore.

The list of foreign members, our only honorary class, has been checked, resulting in a reduction of seven members, some of whom died during the current year and others whose deaths occurred previously.

Appended hereto is the detailed auditor's report. In addition, the auditor has suggested a new and more accurate method of keeping the membership and subscription records, and has set up supplementary methods of accounting that will enable the secretary to conform more nearly with the constitutional requirement that "the general funds of the Association shall be entered and accounted for in such a manner that the financial condition of each activity can be easily determined."

College Park, Maryland
December 8, 1937

Dr. E. N. Cory, Secretary
American Association of Economic Entomologists
College Park, Maryland
Dear Dr. Cory:

In accordance with your instructions, I have supervised the examination of the cash receipts and disbursements of the American Association of Economic Entomologists, and am submitting herewith a statement of receipts and disbursements for the period covered by the audit, together with an auditor's certificate and comments.

Yours truly,
(Signed) S. M. Wedeberg
Certified Public Accountant

Summary of Cash Receipts and Disbursements American Association of Economic Entomologists

For the Period from December 16, 1936, to November 15, 1937

	Total	Journal	Association	Index V	Index IV	Index III	Index I & II
Balance, December 15, 1936, as per previous audit report	$ 8,950.24	$ 3,719.91	$3,585.17	$402.50	$304.50	$163.30	$774.86
Receipts:							
Sales	30.60	.....	.....	.....	4.50	12.60	13.50
Subscriptions, advertising and reprints	6,644.61	6,644.61	.....	.....	.....	.....	.....
Dues and miscellaneous	1,893.75	.....	1,893.75	.....	.....	.....	.....
Interest on bank deposits	46.07	.....	46.07	.....	.....	.....	.....
	$17,565.27	$10,364.52	$5,524.99	$402.50	$309.00	$175.90	$788.36
Disbursements							
Audit of period from Dec. 15, 1935 to Dec. 15, 1936	$ 35.00	.....	35.00				
Printing	4,201.00	4,094.02	106.98				
Engravings, halftones, drafting, etc.	492.86	492.86	.....				
Editor's salary (first half of 1937)	100.00	100.00	.....				
Salary of Secretary and Business Manager	400.00	200.00	200.00				
Postage, stationery and supplies	398.67	206.00	192.67				
Telephone and telegraph	11.44	.....	11.44				
Traveling expenses:							
E. F. Phillips, to Atlantic City, N. J.	29.35	.....	29.35				
L. O. Howard, to Atlantic City, N. J.	36.60	.....	36.60				
T. H. Frison, to Atlantic City, N. J.	73.82	.....	73.82				
Traveling expenses to the meeting of the Committee on the Constitution:							
E. F. Phillips, to New Haven, Conn.	24.20	.....	24.20				
E. N. Cory, to New Haven, Conn.	31.70	.....	31.70				
Convention expenses	54.83	.....	54.83				
Convention exhibit expenses	23.28	.....	23.28				
Branch expenses	35.25	.....	35.25				
Clerical work	504.48	361.37	143.11				
Surety bond of secretary	12.50	.....	12.50				
Rent of safety deposit box	6.60	.....	6.60				
Equipment	17.25		17.25				
Refunds	37.10	33.10	4.00				
Bank collection charges	2.70	.....	2.70				
Transfer to Permanent Fund	500.00	.....	500.00				
Miscellaneous	39.28	33.90	5.38				
	$7,067.91	$5,521.25	$1,546.66				
Balance, November 15, 1937	$10,497.36	$ 4,843.27	$3,978.33	$402.50	$309.00	$175.90	$788.36

The balance is deposited as follows:	
Prince Georges Bank and Trust Company, Hyattsville, Md. (checking account)	$ 7,309.14
First National Bank of Amherst, Mass. (savings account)	3,106.37
Cash on hand (to be deposited)	81.85
	$10,497.36

Permanent Fund American Association of Economic Entomologists

For the Period from December 16, 1936, to November 15, 1937

Balance, December 15, 1936, as per previous report		$17,776.94
Receipts:		
Interest from securities	$ 352.47	
Interest from savings deposits	48.99	
Transfer from association funds	500.00	
Total Receipts	$ 901.46	
Interest credited on U. S. Savings Bonds from date of purchase to November 1, 1937	150.00	
		1,051.46
Balance, November 15, 1937		$18,828.40

The balance is invested as follows:

PAR VALUE	SECURITIES		
$5000	U. S. Savings Bonds, Series A	$3,900.00	
2000	Province of Ontario, 5%	2,000.00	
3000	Federal Land Bank of St. Louis, 4½% (called May 1, 1937)	2,662.50	
1000	Federal Land Bank of Columbia, 4½% (called May 1, 1937)	887.50	
2500	U. S. Treasury Bonds, 3½%	2,484.00	
3000	U. S. Treasury Bonds, 2¾%	2,984.00	
			$14,918.00
Bank deposits (savings accounts):			
	Prince Georges Bank and Trust Company, Hyattsville, Md.	$2,800.52	
	Franklin County Trust Company, Greenfield, Mass.	1,109.88	
			3,910.40
			$18,828.40

NOTE: The redemption of the bonds of the Federal Land Bank of St. Louis and the Federal Land Bank of Columbia will increase the fund by $450.00.

College Park, Maryland
December 8, 1937

Dr. E. N. Cory, Secretary
American Association of Economic Entomologists
College Park, Maryland
Dear Dr. Cory:

I have supervised the examination of the accounts of the American Association of Economic Entomologists for the period from December 16, 1936, to November 15, 1937. In connection therewith, the record of cash receipts has been verified by tests; and the cancelled checks have been compared with the vouchers and with the cash book record of disbursements.

All bank deposits of both the General Fund and the Permanent Fund have been verified by positive confirmations from the depository banks. All interest receipts have been verified in like manner. The securities have been verified by examination and all interest coupons accounted for.

I hereby certify that, in my opinion, the accompanying statements properly set forth the cash receipts and disbursements for the period of this audit, and the balance in custody of the Secretary on November 15, 1937.

(Signed) S. M. WEDEBERG
Certified Public Accountant

EASTERN BRANCH

The Eastern Branch of the American Association of Economic Entomologists met in Philadelphia on November 18 and 19 at the Walton Hotel, with H. N. Worthley presiding. The program included 45 papers on diverse entomological subjects. The attendance was about 150.

The financial report showed receipts of $3,859.08 and expenditures of $1,811.71.

A second revised and enlarged edition of "Entoma, A Directory of Insect Pest Control," was published during the year and met with general approval.

At the Philadelphia meeting the Branch adopted a motion to award an annual medal for the best paper presented at its annual meetings, and committees were set up to carry out its wishes.

V. I. Safro was elected Chairman, C. C. Hamilton, Vice Chairman, and Harry B. Weiss was reelected Secretary-Treasurer for three years.

COTTON STATES BRANCH

The twelfth annual meeting of the Cotton States Branch was held at San Antonio, Tex., on February 18, 19 and 20, 1937. This was a joint meeting with the Texas Entomological Society, the Branch having voted to meet every fourth year in a city west of the Mississippi River. The attendance was considerably larger than that of any previous meeting of the Branch, there being 113 names on the attendance record. Sessions on three days and two nights were required to complete the program which included six symposia dealing with insects of special interest to Southern entomologists. Fifty papers were presented during the meeting. The President and First Vice-President of the American Association of Economic Entomologists and the chief and eight heads of divisions of the U. S. Bureau of Entomology and Plant Quarantine attended the meeting. The annual banquet was held on the night of February 18 with L. A. Strong as toastmaster and F. A. Fenton as speaker.

The Secretary-Treasurer reported receipts of $253.43, and expenditures of $52.89, leaving a balance of $200.54.

W. E. Dove, San Antonio, Tex., and E. O. Eddy, Baton Rouge, La., were elected Chairman and Vice Chairman, respectively, and Oliver I. Snapp, Fort Valley, Ga., was re-elected Secretary-Treasurer for a three-year term.

New Orleans, La., was designated as the place for the thirteenth annual meeting, which was scheduled for Feb. 3, 4 and 5, 1938.

PACIFIC SLOPE BRANCH

The twenty-third annual meeting of the Pacific Slope Branch was held in Denver, Colo., June 24 and 25, under the chairmanship of E. J. Newcomer, Yakima, Wash. Between 45 and 50 members and persons interested in entomology were present. Twenty-two papers were presented, which included a number on grasshoppers and grasshopper control. The invitation address was given by Dr. C. P. Gillette, Fort Collins, Colo., who gave an illustrated discussion of "Adaptation to Environment in Super-Family Aphoidea."

On the evening of the twenty-fourth, the banquet was held, at which the members were addressed by Dr. C. P. Gillette and Dr. R. A. Cooley.

In addition to members resident on the Pacific Coast, there were a number of visiting entomologists, including Dr. R. H. Beamer from Kansas, Mr. M. P. Jones from Washington, D. C., and Mr. A. Fenton from Texas.

The Secretary-Treasurer, J. F. Lamiman, reported receipts of $17.28 and expenditures of $19.66, leaving a balance of $16.66.

J. R. Eyer, State College, N. M., was elected Chairman of the Branch; W. C. Cook, Modesto, Calif., Vice Chairman; and J. F. Lamiman, Davis, Calif., was continued as Secretary-Treasurer.

ERNEST N. CORY, *Secretary and Business Manager*

It was moved, seconded and carried that the report of the Secretary and Business Manager be accepted.

REPORT OF THE EXECUTIVE COMMITTEE

1. Owing to the pressure of official duties, Lee A Strong resigned from the Executive Committee shortly after the last annual meeting, and E. F Phillips was appointed as an interim member of the committee.

2. Your committee has held four meetings during the year.

3. In accordance with the resolution passed at Atlantic City, a special committee on the Constitution was appointed to consider and report on the redraft of the Constitution, prepared by the Executive Committee. The Constitution Committee has worked energetically and seriously in the preparation of the new draft that will be voted upon on Thursday morning. It should be distinctly understood that this document is solely a working plan for this Association, and has no connotation in connection with any federation that may be formed in the future.

4. In order to encourage more individuals to become life members, it is recommended that the $100.00 fee may be received in installments provided the entire amount is paid in any one calendar year.

5. Cooperation with other agencies in the preparation of an entomological program for the summer meeting of the A.A.A.S. at Ottawa, June 27 to July 2, 1938, was recommended, and the incoming President authorized to appoint a committee for this purpose.

6. The present advertising policy of the JOURNAL was approved, and it was recommended that efforts be made to increase the amount of advertising carried.

7. It was recommended that every effort be made to meet the request of the Eastern Branch that their proceedings be published as a unit.

8. Due to the change made at the St. Louis meeting in the price of the JOURNAL, and the amount of the dues, it was recommended that the action of the Association in 1925 relative to the cost of reinstatement of members be rescinded, and that hereafter the JOURNAL be sent to those who are one year in arrears, and those members who are two years in arrears will be subject to being dropped from the rolls; reinstatement to be made only upon payment of all arrears and dues for the current year.

9. A standing committee of three was recommended, this to be known as the Committee on Cooperation with the Pest Control Operators; one member to serve three years; one, two years; and one, one year; replacements on the committee to be elected for three years.

10. A standing committee of three was recommended, this to be known as the Committee on the Relation of Entomology to Conservation; the selection of the members to be made on the same basis as in the above committee.

11. The publication of Index V was authorized and the contract for the printing has been awarded. The volume should appear about April 1.

12. A sale of 200 sets of Indices I, II, III and IV was authorized at a rate of $10.00 for the four volumes, which formerly sold for $17.00; this was done in order to reduce the inventory.

REPORT OF THE TRUSTEE FOR THE TROPICAL PLANT RESEARCH FOUNDATION

As your representative on the Board of Trustees of the Tropical Plant Research Foundation, I present herewith a brief report, although there have been no operations of a nature to be reported upon during the past year. There have been some steps taken toward an affiliation with the Pan-American Union; but, according to my latest information, no decisive action has been taken and no definite report can be made. We are assured, however, that the organization of the Foundation has been main-

tained, and it will be able to function in case any opening appears where it could perform a useful service.

—HERBERT OSBORN

REPORT OF THE COUNCILORS FOR THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

The meetings attended presented no reports of particular interest to entomologists. Most of the reports dealt with routine matters.

—ALVAH PETERSON

REPORT OF THE COMMITTEE ON COMMON NAMES OF INSECTS

No new list was submitted this year. In Volume 30, Number 3, pages 527–560, a complete list of all names already approved by the Association, 999 in number, was printed. These are offered for sale as a separate.

So few new names were suggested during the current year that the Committee feels it inadvisable to submit a list for approval at this time.

Your Committee would like to recommend that the Association, having endorsed these names, make it obligative that if any common names are used on and after January 1, 1939, they be used in the JOURNAL OF ECONOMIC ENTOMOLOGY, and that the editorial staff refuse to accept for publication articles in which the author refuses to adopt the names approved by the Association. There should be no objection, however, to indicating in parenthesis a colloquial name in addition to the name approved by the Association.

—J. A. HYSLOP, *Chairman*
B. B. FRIEND
H. B. HUNGERFORD
L. M. PEAIRS
H. S. SMITH
WILLIAM J. BAERG

(This report was received at the second session of the Executive Committee, and the recommendations were adopted at the final business session.)

COMMITTEE ON INSECT COLLECTIONS

(No report concerning private insect collections was presented. This was in conformance with the action taken last year. C. F. W. Muesebeck, Chairman, presented the report of the committee pertaining to the most important additions to institutional insect collections which, according to established custom, is published in the Annals of the Entomological Society of America.)

REPORT OF THE COMMITTEE ON THE CODLING MOTH

The Committee on the Codling Moth has continued its activities as in recent years. A general conference was held at Atlantic City on December 31, 1936, following the close of the meetings of this Association. The minutes of this conference have been made available to all of those who participated, and to others interested who have requested them.

Arrangements are being made to hold the next general conference at Spokane, Wash. on January 26 and 27, 1938. This is in accordance with the policy recently adopted by the Committee, to rotate the places where conferences are held among the various regions of the country where important codling moth work is under way. Since many of the eastern and middle-western entomologists will not be able to make the trip to Spokane this winter, a brief conference was also held at Indianapolis on the afternoon of December 27, 1937, preceding the meetings of the Association.

At the request of your Committee the Bureau of Entomology and Plant Quarantine has continued to serve as a clearing house for information on the results of current investigations. The customary pool of information on the results of investigations carried on in 1937 has been prepared. This year the invitation to furnish information was also extended to the research workers employed by insecticide companies. The section dealing with the investigations carried on by state agencies, the Entomological Branch of the Canadian Department of Agriculture, and the research staff of one insecticide company which availed itself of the opportunity to contribute its results, was placed in the mails December 18. Certain contributions which were received too late for inclusion at that time will be later issued as a supplement. The portion of the pool relating to the investigations carried on by the Bureau of Entomology and Plant Quarantine was prepared in time for distribution to those present at the Indianapolis conference and is now being sent out to the regular mailing list.

—B. A. PORTER, *Chairman*
J. S. HOUSER
P. J. PARROTT
W. A. ROSS
R. L. WEBSTER
H. N. WORTHLEY

REPORT OF THE COMMITTEE ON THE PROMOTION OF OFFICIAL ENTOMOLOGY

During the past year inquiries were made regarding suggested changes in federal appropriations for entomological work, and there has not seemed to be any occasion when formal action of this Committee was indicated.

It seems proper in this report to call the attention of the Executive Committee and others interested to the proposed balancing of the federal budget. The danger of the more important lines of entomological work seems to lie in the possibility that, in reducing appropriations, there may be a reduction in certain vital items, even to the point of their elimination, in order that some less vital governmental activity, either in or outside the Bureau of Entomology and Plant Quarantine, may be supported. This may, therefore, mean that the Committee will have important work to do in preserving the integrity of the work, in maintaining the most useful and important lines of investigation and regulation, and in preserving the organization of the Bureau itself from further proposals of reorganization which might be seriously detrimental. While at present we are faced only with a possibility, it seems proper to call attention to the fact that this Committee should be suitably empowered to hold meetings and to make essential expenditures if and when such actions are indicated by the discussions of appropriation bills. Attention should further be called to the fact that this Committee is formed

to serve both the entomological organizations, so that suitable authority is needed from both sides.

—E. F. PHILLIPS, *Chairman*
J. J. DAVIS
T. J. HEADLEE

REPORT OF THE REPRESENTATIVE ON THE NATIONAL RESEARCH COUNCIL

For the current year (1937), and until 1940, the representative of the American Association of Economic Entomologists will according to the established practices, serve as the representative of Society Group VIII of the Division of Biology and Agriculture of the National Research Council. The other societies of this group, whose representatives for this period are designated as "advisory representatives," are American Society of Mammalogists, Entomological Society of America and American Society of Parasitologists.

The activities of the Division of Biology and Agriculture of the National Research Council, during the past year, have continued along the same general lines of previous years. Many of the problems presented to and undertaken by the Division involve matters requiring time-consuming study. The reports of standing committees show continued activity and progress. The work of the committee on radiation is a very good example of the progress made through the activities of the Division, and the reports published by and under the endorsement of the National Research Council have contributed much in this field of interest and aid to entomological research.

One of the committees which has been working for some years, and which has been particularly active during the present one, is concerned with the preservation of natural conditions of plant and animal life, particular attention being given to grasslands as a basis of studies on ecology. Inspections of certain grassland areas were made by the committee last season with the view of the possibility of recommending that they be set aside as a grassland national park. Insects and their relation to such areas are a matter of no little importance, and the work of this committee and its recommendations will be of particular interest to entomologists.

The recently established committee on aerial dissemination of pathogens and allergens, the program of which is being formulated, while not directly bearing on entomology, should develop information and procedures applicable to problems on insect movement and distribution.

The third edition of the "Handbook of Scientific and Technical Societies of the United States and Canada" issued in October, 1937, as Bulletin 101 will be a useful reference to those interested in obtaining information on the history, scope and objects of the various groups organized in the interest of entomology. Entomological societies are discussed as well as many other organizations which cover fields bearing on the science of entomology, restricted and applied.

A casual review of the fellowships granted by the National Research Council justifies the renewal of earlier comments to the effect that entomology is conspicuous by its absence. Are we to conclude that entomological work is so well supported that investigations in this field go forward without the aid sought by other sciencies, or are we just poorer salesman? The answer is not apparent and may deserve an inquiry.

The National Research Council has received an invitation to send a representative to the International Congress for Entomology which is to convene in Berlin during August, 1938. The Council advises it can make no financial provision for attendance at this Congress but would consider designating as its representatives one or more persons of distinction who plan to attend, and they request nominations from the Association.

—S. A. ROHWER

REPORT OF REPRESENTATIVES ON COUNCIL OF UNION OF AMERICAN BIOLOGICAL SOCIETIES

Your representatives attended the annual meeting of the Union of American Biological Societies, Wednesday evening, December 29 in the Claypool Hotel, Indianapolis. The matter of chief concern was the proposed plan for financing *Biological Abstracts*.

The Rockefeller Foundation having terminated the support which it has given to *Biological Abstracts* over the past eleven years, the Acting Editor and a Special Committee on Arrangements, appointed by the Board of Trustees of *Biological Abstracts*, announced in *Science* for December 17 a new financing plan, the essence of which is that each institution is to become a master subscriber, the annual cost of a master subscription varying with the number of biologists affiliated with the institution, from $25 for institutions having up to three biologists, to $200 for institutions having 51 or more biologists on their staff. Any number of additional copies might be purchased by a master subscriber at $7 per volume.

It was further proposed to ask each biological association to collect from each of its members $3 per year to be given to the support of *Biological Abstracts*. No American biologist could be a member of any biological society without assuming this obligation. No member, however, would be asked to pay more than $3 per year, regardless of the number of biological societies to which he belongs. By payment of an additional $4 annually, any biologist could secure a subscription to *Biological Abstracts* provided his institution holds a master subscription.

It was proposed that, following a one- or two-year period, during which the master subscription would be graded according to the number of biologists in the institutions, the *Abstracts* would be furnished to institutions on a flat rate basis, the actual cost yet to be determined, but the $3 per year assessment upon all biologists would continue permanently.

At the meeting on December 29, a number of affiliated biological associations indicated that the proposed plan of financing would not be approved by their associations. Only a few had voted an assessment and this was $2 a year instead of the proposed $3. The councils of other societies were willing to approve, only subject to a referendum of their membership, and most of those reporting approved an assessment of $2 only upon such of their members as hold the rank of instructor or above, or the equivalent thereof in other work. Several societies reported a flat repudiation of the proposed scheme of financing.

It would appear, therefore, that this plan upon which the management of *Biological Abstracts* has, at the eleventh hour, taken its last stand, has no hope of being consummated.

Your representatives on the council desire to register their disapproval of the apparent aim of the management of *Biological Abstracts* to place the stigma for the failure of this subject, upon which eleven years and Rockefeller grants of over three-quarters of a million dollars have been sacrificed, upon the biological associations, instead of squarely upon the management of *Biological Abstracts*, where it belongs.

—W. A. PRICE
C. L. METCALF

Following the adoption of the above report, the following motion was passed:

In view of the fact that the literature concerning economic entomology published throughout the world is very ably abstracted by the Review of Applied Entomology, that American literature concerning economic entomology is well indexed by publications of the American Association of Economic Entomologists, that the Zoological Record provides an excellent index of taxonomic and other entomological literature not of an economic nature and that other useful bibliographical sources exist, it is moved that the American Association of Economic Entomologists disapprove the suggestion that each member be assessed $3 annually for the support of *Biological Abstracts* and continue the support of its members of the abstracting and indexing publications mentioned above.

REPORT OF THE COMMITTEE ON POPULAR ENTOMOLOGICAL EDUCATION

Last year this Committee made a survey of the extent to which entomology had gained recognition in the press. The press clippings were voluntarily submitted by the collaborators of the survey. This led to a bias as those particularly interested in a given project clipped on the subject in which they were particularly interested and gave undue importance to the amount of publicity being received by that particular subject.

This year, through the courtesy of the Department of Commerce, we received clippings from 388 newspapers clipped by unbiased reviewers. In the following table we give the number of papers from each state:

Alabama	4	Nevada	2
Arizona	2	New Hampshire	2
Arkansas	3	New Jersey	9
California	19	New Mexico	3
Colorado	12	New York	30
Connecticut	6	North Carolina	6
Delaware	1	North Dakota	3
Florida	7	Ohio	17
Georgia	8	Oklahoma	6
Idaho	3	Oregon	4
Illinois	13	Pennsylvania	15
Indiana	10	Rhode Island	2
Iowa	7	South Carolina	5
Kansas	6	South Dakota	3
Kentucky	1	Tennessee	12
Louisiana	3	Texas	50
Maine	4	Utah	4
Maryland	6	Vermont	2
Massachusetts	14	Virginia	6
Michigan	9	Washington	5
Minnesota	9	Washington, D. C.	7
Mississippi	6	Wisconsin	12
Missouri	12	Wyoming	3
Montana	6	West Virginia	5
Nebraska	4		

Texas led with 50 newspapers, followed by New York with 30 and California with 19.

In these papers there were over 13,000 inches of space devoted to entomological articles or approximately 84 full pages of newspaper print. There was a grand total of 1,393 articles. The New York newspapers led with 1,435 inches of column space, Colorado followed with 1,219 inches, and Texas with 1,082 inches.

The amount of material appearing in the columns in the several states is listed in the following table:

	Articles	Inches
New York	138	1435.5
Colorado	71	1219.0
Texas	114	1082.0
Utah	84	747.0
California	52	418.5
Pennsylvania	35	367.5
Maryland and Washington, D. C.	49	356.5
Tennessee	33	354.0
Montana	40	342.5
Virginia	33	308.0
Illinois	53	306.5
Georgia	34	305.5
South Dakota	31	298.5
Massachusetts	33	296.5
Ohio	28	295.0
Minnesota	17	285.5
Missouri	42	280.0
Wisconsin	36	273.0
Nebraska	40	271.5
Kansas	20	257.0
Indiana	37	238.5
Michigan	26	208.5

The subjects treated in these newspaper accounts covered a very broad field and occupied 4,622 inches of column space. The most frequently published articles dealt with grasshoppers, a natural result of the terrific outbreak occurring in the plains states. Following grasshoppers in decreasing order were the Japanese beetle, the black stem rust and truck crop insects.

The following table lists the 22 most frequently treated subjects:

Grasshoppers	4622.5	Quarantines	192.0
Black stem rust	550.0	Parasites	190.5
Japanese beetle	592.5	Insecticides	190.0
Truck insects	438.5	Periodical cicada	174.0
Mormon cricket	423.0	Fruit insects	190.0
Boll weevil	367.0	Man and animals	142.5
Armyworm	357.5	Screwworm	135.0
White-fringed beetle	347.0	Cotton flea hopper	135.0
Forest insects	370.5	Mosquitoes	119.5
Dutch elm disease	215.0	Termites	118.0
Pink bollworm	211.5	Codling moth	105.0

It was too great a task to attempt with the time available to analyse the source of all this information. An analysis was made however of the reports on grasshoppers. Of the 4,622 inches devoted to this subject, 781 inches were credited to the state entomologists, 712 inches to the county agents, 371 inches to the extension entomologists, 295 inches to the U. S. Department of Agriculture and 170 inches to the state agriculture colleges and experiment stations. The balance of the material was from newspaper correspondents and anonymous writers; much of this undoubtedly had its origin

in one of the previous-mentioned sources. The outstanding feature of this analysis was that the county agents and the extension entomologists, in other words, the extension service was the most fruitful means of spreading entomological information through the press, accounting for over 1,000 inches of column space. The next source was the state entomologist.

During the year the U. S. Bureau of Entomology and Plant Quarantine released 67 press releases and 56 radio releases over the air.

—J. A. HYSLOP, *Chairman*
E. O. ESSIG
C. J. DRAKE

REPORT OF THE TRUSTEES FOR CROP PROTECTION INSTITUTE

The following are the fully organized research projects of the Crop Protection Institute, as of December 1, 1937. These are in addition to preliminary or exploratory work, some of which is expected to develop into regular, organized projects.

ATLANTIC REFINING PROJECT.—Atlantic Refining Co., Philadelphia. To run for one year, January 1, 1937 to December 31, 1937. George L. Walker. Investigator. Headquarters, Experiment Station, New Haven, Conn. Working under immediate direction of Dr. W. E. Britton, Dr. Philip Garman, Neely Turner. These men, together with Dr. W. C. O'Kane, constitute the technical committee.

The purpose of this project is to determine the performance and value of a sulfonated product known as Ultrawet, developed in the research laboratories of Atlantic Refining Co. This material is being used experimentally in combination with various insecticides. Ultrawet is a contact agent which also possesses some adhesive properties. It has a greater safety margin on plants than is possessed by other similar materials. Combinations with insecticides have given good performance. Also, combinations with sulphur have given good results. Work in collaboration at the Colorado and Riverside, Calif., stations, has been in progress this summer as a part of this project.

DX PROJECT.—J. C. Makepeace, Wareham, Mass., Alfred G. Kay, Chester, N. J., Asher Capelle, Investigator. Headquarters, Experiment Station, Durham, N. H. Working under immediate direction of Dr. W. C. O'Kane. Headquarters of this work have been in various places at various times, but especially in Delaware and in Indiana.

This project represents the continuation of extensive studies of the past three years, to evaluate a new type of spray base and to bring about improvements in the composition of the base. Several formulae are involved utilizing different toxicants, including pyrethrum, nicotine, derris and thiocyanates.

NATIONAL ANILINE PROJECT.—National Aniline & Chemical Co., Inc., 40 Rector St., New York City. To run for one year, January 1, 1937 to December 31, 1937. John W. Heuberger, Investigator. Headquarters, Experiment Station, Newark, Del.

The purpose of this project is to develop an effective fungicide based on a detergent which was worked out in the research laboratories of the National Aniline Co., and which is known by the laboratory symbol "Detergent 66." Improvements in performance were developed by Dr. Adams and Dr. Heuberger, resulting in materials known by the symbols "Fungicide 66A" and "Fungicide 66B." The latter gave excellent results in extensive field tests in the summer of 1937.

DOW PROJECT.—Dow Chemical Company, Midland, Mich. To run to December 31, 1937. Dr. J. Franklin Kagy, Investigator. Headquarters, Experiment Station, Riverside, Calif. Previously, Experiment Station, Ames, Iowa. Noal P. Larson, doing part time work at Ames, Iowa, under immediate direction of Dr. Charles H. Richardson.

In this project a long series of organic compounds have been studied. These compounds originated with the research laboratories of Dow Chemical Company. In part they have been under test as possible additions to oil sprays (both dormant and summer oils) and in part as additions to household spray kerosene, either to take the place of pyrethrum extract or as a supplement. One material developed in this project, dinitro ortho cyclo hexyl phenol, has been successfully incorporated in a dormant oil spray and is on the market. Other materials are in process of study.

ROHM & HAAS PROJECT.—Rohm & Haas Co., 222 W. Washington Square, Philadelphia, Pa. To run for one year, July 1, 1937 to June 20, 1938. Ross F. Suit, Investigator, with headquarters at Experiment Station, Geneva, N. Y. Working under immediate direction of Dr. J. G. Horsfall, Dr. O. A. Reinking, Geneva, N. Y. Committee: Dr. J. G. Horsfall, Geneva, N. Y., Dr. W. H. Martin, New Brunswick, N. J., Dr. S. E. A. McCallan, Boyce Thompson Institute, Yonkers, N. Y.

This project is organized around cuprous oxide as manufactured by Rohm & Haas Co. This is a stabilized red copper oxide. Elaborate studies have been made with reference to control of diseases of hops, roses, cherries and other crops. Considerable work has been done on utilization of the material for seed treatment on peas.

STANDARD CHEMICAL PROJECT.—Standard Chemical Products, Inc., Thirteenth and Adams Sts., Hoboken, N. J. To run for one year, January 15, 1937 to January 15, 1938. Warren A. Westgate. Investigator, with headquarters at Experiment Station, Durham, N. H. Working under immediate direction of Dr. W. C. O'Kane.

This work was originally laid out as a study of two insecticides introduced from France for experimental purposes. The materials carry the names Elgetol and Elgete, and are a winter spray and a summer spray respectively. As the work progressed, a third material was developed which utilizes rotenone as its toxic agent. Also, a herbicide was imported from France and has been given extensive tests this summer, with the cooperation of the Botany Department of the University of New Hampshire.

GENERAL CHEMICAL PROJECT NO. 1.—General Chemical Co., 40 Rector St., New York City. To run for one year, to January 14, 1937. Headquarters in Lafayette, Ind. Work finished at end of project year, but additional work now going on in Louisiana, under direction of Dr. C. O. Eddy. The purpose of the project was to develop a material for codling moth control, which would be free of at least some of the objections of lead arsenate. The material under most extensive study has been a basic zinc arsenate. Results of these studies, including extensive field plots, have indicated a field of utility for basic zinc arsenate as a follow-up where lead arsenate is used for early season sprays.

GENERAL CHEMICAL PROJECT, NO. 2.—General Chemical Company. To run for one year, to March 1, 1938. Exploratory work at experiment station, Baton Rouge, La. E. H. Floyd, Investigator, short-term employment. Work under immediate direction of Dr. C. O. Eddy. Also exploratory work at experiment stations at College Park, Md., State College, Miss., Riverhead, N. Y., State College, Tex., Norfolk, Va., Riverside, Calif., and New Haven, Conn.

The primary objective of this project is a study of various forms of calcium arsenate, both alone and in combination with other substances.

GENERAL CHEMICAL PROJECT, NO. 3.—General Chemical Co. Exploratory work in Baton Rouge, La. This project is set up to include miscellaneous substances.

MONSANTO PROJECT.—Monsanto Chemical Company, St. Louis, Mo., running for one year to July, 1937. C. W. Kearns investigator. Work under the immediate direction of W. P. Flint, Illinois Natural History Survey and Illinois Agricultural Experiment Station, Urbana, Illinois.

This work reached a logical conclusion in July of 1937. It consisted of thorough study of various organic compounds originated in the research laboratories of the Monsanto Chemical Company. Out of these studies at least two compounds have been developed which are expected to meet rather wide use as insecticides. In addition, certain compounds were given attention as possible fungicides under the direction of Dr. H. W. Anderson, of the Illinois experiment station.

PUBLICATIONS.—Bulletins published during the year have been as follows:

No. 61, "Contact Insecticidal Properties of Various Derivatives of Cyclohexylamine," by C. W. Kearns and W. P. Flint.

No. 62, "Evaluation of Cuprous Oxides Recommended as Seed Treatments for the Control of Damping-Off," by H. W. Anderson, K. J. Kadow and S. L. Hopperstead.

No. 63, "Copper Sulfate as a Plant Nutrient and Soil Amendment," by W. L. Churchman, M. M. Manns and T. F. Manns.

The Crop Protection Institute Circular has been issued throughout 1937, under the editorship of J. J. Davis, and has enlisted wide interest.

—C. H. RICHARDSON
W. C. KANE
J. J. DAVIS

REPORT OF THE COMMITTEE ON COOPERATION WITH THE NATIONAL PEST CONTROL OPERATORS ASSOCIATION

The Committee would like to make the following suggestions:

1. That the Secretary of the American Association of Economic Entomologists ask each branch to consider devoting one-half day of its branch meeting to the discussion of household pest control problems, and that so far as possible the branch notify the pest control operators in their area of the time and place when such a symposium will be held;

2. That we welcome suggestions from the Committee of the Pest Control Operators as to lines of research work which they would like to have taken up in the various sections of the country, and that such suggestions be given to the Chairman of the Pest Control Operators Committee of the American Association of Economic Entomologists. The Committee feels that the entomologists of various states should carefully consider the matter of legislation dealing with Pest Control Operators; that it would be helpful if, as many of these entomologists as possible furnish suggestions to the Pest Control Committee of the American Association of Economic Entomologists; that such suggestions be used by this Committee to draw up a model law, copies of which could be distributed to any entomologist or pest control operator desiring them.

PEST CONTROL OPERATORS COMMITTEE	ASSOCIATION OF ECONOMIC ENTOMOLOGISTS:
—CHARLES DENNY, *Chairman*	—J. J. DAVIS
MAX RUKIN	J. G. SANDERS
GEORGE HOCKENYOS	E. A. BACK
	NEELY TURNER
	W. P. FLINT

REPORT OF THE COMMITTEE ON THE RELATION OF ENTOMOLOGY TO CONSERVATION

A preliminary survey by your Committee has disclosed the following:

Modern man has been ruthlessly destructive and extravagantly wasteful in his exploitation of the natural resources of the earth, and in his efforts to make a varied and complex environment better suited to his needs or to his whims. With advancing social maturity, however, and largely within the memory of men still living has come a slowly dawning public realization that conservation and restoration must replace wasteful exploitation.

As with most newly conceived general movements, conservation activities, including entomology, still consist too largely of uncoordinated efforts to attain divers objectives, without due concern for resulting interactions.

Such uncoordinated conservation activities have often worked at cross purposes; one sometimes striving earnestly to do what another may be striving just as earnestly to undo.

Insect problems in one way or another touch nearly every human interest and are concerned directly or indirectly with nearly every human activity. This is especially true of conservation interests and activities. For example:

In flood control, reservoirs may eliminate mosquito breeding swamps or marshes, but may create new ones.

In erosion control, retaining vegetation on terrace embankments may harbor insect pests; while brush dams and the like may hold mosquito breeding water.

In game management, thickets along fence rows recommended for cover may harbor crop pests; water impounded for aquatic birds may produce mosquitoes; while undue local concentration of waterfowl and other forms of wildlife may favor the dissemination of insect-borne and other diseases of such animals.

In crop pest control, clean culture to minimize hibernation and to eliminate reservoir host plants and the like, may reduce the available cover and food for wildlife.

In mosquito control, drainage of upland swamps and marshes will bring attendant changes in wildlife habitats and wildlife populations.

In reforestation work, planting solid stands of a single tree species may invite attack by insect pests, and may increase control requirements beyond profitable limits; while properly planned mixed planting may reduce the number and intensity of insect outbreaks, and thus reduce or eliminate expensive control requirements.

Similar examples could be cited without end. *THEREFORE,* it is the considered judgment of your Committee:

That insect problems are practically co-extensive with and inseparable from conservation problems.

That the interrelation of such problems has had scant consideration.

That conservation programs must be adjusted and readjusted from time to time to conform with specific knowledge.

That in the relation of entomology to conservation there is urgent need for a more general understanding, and for planned coordination.

That some continuing agency should be created by the American Association of Economic Entomologists to act as a fact finding body, to advise the Association concerning general policies and particular problems and to cultivate cooperative relations with similar agencies if and when created by other organizations concerned.

That, to this end, there should be appointed a standing committee on the Relation of Entomology to Conservation, of which appropriate subcommittees may be assigned to work on various phases of the general problem.

—CARL J. DRAKE, *Chairman*
ROBERT D. GLASGOW
T. H. FRISON

REPORT OF THE MEMBERSHIP COMMITTEE

The following 71 names are recommended for election as active members of the Association:

Frank App, Bridgeton, N. J.
James W. Apple, 118 W. Oakland Ave., Columbus, Ohio
Edward H. Arnott, Arnott Exterminating Co., 247 Massachusetts Ave., Indianapolis, Ind.
Fitz James Bartlett, University of Florida, Gainesville, Fla.
William H. Bennett, Dept. of Forest Ent., Syracuse University, Syracuse, N. Y.
Fred R. Biederman, Fort Warren, Wyo.
Robert L. Blickle, Box 486 Thompson Hall, Durham, N. H.
R. Sidney Braucher, 3490 Chicago Ave., Riverside, Calif.
E. G. Brewer, 266 Glenwood Ave., Bloomfield, N. J.
Lester Bridges, 330 Michigan Ave., McComb, Miss.
Albert W. Buzieky, 487 St. Clair St., St. Paul, Minn.
Erwin L. Carpenter, 20 Cedar Drive, Old Greenwich, Conn.
E. Maurice Chauvaud, 734 Key Route Blvd., Albany, N. Y.
Beckford F. Coon, 202 E. Seventh St., Moscow, Idaho
Luis Adolfo Costas, Exp. Sta., University of Porto Rico, Jauna Diaz, P. R.
Herbert A. Crandell, 1436 Meadow Road, Columbus, Ohio
Clarence B. Dominick, Blacksburg, Va.
C. K. Dorsey, 4609 Cleveland Ave., St. Louis, Mo.
Howard Earl Dorst, Agrl. College, Logan, Utah.
Charles B. Eaton, 335 Giannini Hall, U. of C., Berkeley, Calif.
R. D. Eichmann, Zool. Dept., State College, Pullman, Wash.
Max H. England, 543 North 5th, Covina, Calif.
William C. Ferguson, 800 Wood St., Wilkinsburg, Pa.
John H. Gayden, Experiment Station, University, La.
F. W. Geise, American Can Co., Chicago, Ill.
Joseph A. Gillett, 436 Third Ave., Twin Falls, Idaho
Bruce D. Gleissner, Botany and Zoology Bldg., Ohio State University, Columbus, Ohio
Lyle D. Goodhue, Box 242, Berwyn, Md.
James McD. Grayson, V. P. I., Blacksburg, Va.
Melville H. Hatch, University of Washington, Seattle, Wash.
A. D. Hess, Comstock Hall, Cornell University, Ithaca, N. Y.
Richard T. Holway, South Duxbury, Mass.
Edwin W. Howe, Box 952, Santa Cruz, Calif.
Theodore R. Hupper, 191 Pioneer Hall, University of Minnesota, Minneapolis, Minn.
George H. Kaloostian, State College, Fresno, Calif
Herbert Knutson, Univ. Farm, St. Paul, Minn.
W. H. Lange, Jr., Half Moon Bay, Calif.
W. Ray Lapp, Plant Inspection Office, Room 635, Dominion Public Bldg., Windsor, Ont., Can.
N. P. Larson, Insectary, State College, Ames, Iowa
Kwah-Si Liu, Farm School, St. Paul, Minn.
Horace O. Lund, Div. of Biol. Sciences, University of Georgia, Athens, Ga.
A. M. Massee, Research Station, East Malling, Kent, England
Harry C. McLean, Exp. Sta., New Brunswick, N. J.
John Medler, University of Minnesota, St. Paul, Minn.
John K. Medoff, 764 Bergenline Ave., Union City, N. J.
Martin T. Meyer, 213 South 10th St., Philadelphia, Pa.
William Middleton, 266 Glenwood Ave., Bloomfield, N. J.
Robert E Miller, c/o Blue Mountain Canneries, Dayton, Wash.
H. A. U. Monro, Dominion Fumigation Station, 785 Mill St., Montreal, Can.
C. A. Murray, Baldwin Laboratories Saegerstown, Pa.
Victor E. Nygren, Dept. of Ent., University of Idaho, Moscow, Idaho
William J. O'Neill. 94 Church St., New Brunswick, N. J
George W. Pearce, Experiment Station, Geneva, N. Y.
Walter E. Peay, 321 7th Ave., North Twin Falls, Idaho
Price Piquett, Catonsville, Md.
Robert F. Portman, 3465 S. Emerson, Englewood, Colo.
Waltere Ripper, Hadersdorf-Weidingaub, Wien, Austria
Milton W. Sanderson, Dept. of Ent., Univ. of Arkansas, Fayetteville, Ark.
F. J. Schneiderhan, The Chipman Chemical Co., Bound Brook, N. J.
N. A. Sheals, 3129 Key Boulevard, Arlington, Va.
Stanley S. Sheffield, 308 Custom House, New Orleans, La.
Cameron Siddell, Freeport, Tex.
Myron W. Smith, 38 W. Woodruff Ave., Columbus, Ohio

Phillip Carlton Stone, 1114 West Clark St., Urbana, Ill.
William E. Tomlinson, Jr., 819 Watertown St., West Newton, Mass.
William M. Upholt, 112 Ag. Hall, Univ. of California, Berkeley, Calif.
Clyde Vaughn, 36 Pico St., Pasadena, Calif.
Kenneth F. Wilson, California Spray-Chemical Co., San Jose, Calif.
Elton N. Woodbury, 225 West Lincoln Ave., Delaware, Ohio
J. S. Yuill, 335 Giannini Hall, Univ. of Calif. Berkeley, Calif.
John W. Zukel, Dept. of Ent., University of Idaho, Moscow, Idaho

It is recommended that the present foreign members of the Association be transferred to Honorary membership to conform to the provisions of the new constitution.

—WILLIAM MOORE, *Chairman*
A. F. SATTERTHWAIT
W. P. FLINT

(It was moved and seconded that the recommendations of the Membership Committee be accepted. Carried.)

REPORT OF THE RESOLUTIONS COMMITTEE

RESOLVED, That the thanks of this Association be extended to the local committee for the excellent arrangements made in connection with the holding of this, the fiftieth meeting of the Association.

RESOLVED, That this Association extend thanks to the officers and members of the Entomological Society of America and of the American Phytopathological Society for the excellent contributions provided for the joint session relating to insects and diseases

RESOLVED, That the thanks of this Association be extended to Miss Dessa Byrd, H. R. Painter and the Stephen Foster Quartette for the very enjoyable entertainment provided for our annual banquet.

RESOLVED, That this Association extend to the Secretary of Agriculture and the Dominion of Canada Minister of Agriculture its appreciation for the continued assistance provided to develop entomological investigations in both countries.

RESOLVED, That this Association recommend to the incoming President the desirability of appointing a special committee to assist in the preparation of an entomological program for the summer meeting of the A.A.A.S. to be held in Ottawa, Canada, June 27 to July 2, 1938.

IN VIEW OF THE FACT that many of our destructive insect pests recognize no international boundary, be it

RESOLVED, That this Association place on record its appreciation for the holding of group meetings between the entomologists of the United States and Canada, and express the hope that such action be developed as occasion warrants.

RESOLVED, That the thanks of the Association be extended to Prof. P. J. Parrott for the delightful and instructive address given at the joint dinner with members of the Entomological Society of America.

RESOLVED, That the thanks of the Association be extended to the management of the Lincoln Hotel for accommodations and courtesies extended during our meeting.

—GEORGE M. LIST, *Chairman*
FRANKLIN SHERMAN
ARTHUR GIBSON

REPORT OF ADVISORY COMMITTEE, JOURNAL OF ECONOMIC ENTOMOLOGY

The Committee met twice during the Fiftieth Annual Meeting of the Association, discussing many matters pertaining to the publication of the JOURNAL, the review of manuscripts and general policies to be followed in their appraisal. At the first meeting, the Committee made the following recommendations:

1. That the program of the Annual Meetings be no longer published in the JOURNAL; instead, that separate programs be mailed to members well in advance of these Meetings.

2. That the publication of manuscripts in order of acceptance remain the general policy of the JOURNAL and that the Editor be authorized to make exceptions to this policy at his discretion.

3. That the following persons be nominated to serve as officers of the JOURNAL OF ECONOMIC ENTOMOLOGY for the year 1938:

Editor, T. H. Frison
Associate Editor, H. B. Weiss
Business Manager, E. N. Cory
Honorary Editor, E. P. Felt

At the time of the second meeting, the matter of increasing the page size and format of the JOURNAL was considered. The arguments for and against such a procedure were discussed at considerable length by all members in attendance. Statements pertaining to this subject were also made by K. W. Dean, representing the George Banta Publishing Company, present publishers of the JOURNAL. At this meeting the Advisory Committee approved and recommended for adoption by the Association the following:

4. That the page size of the JOURNAL be increased to enable the use of a two-column format to offset rising publication costs, and to permit greater flexibility in the handling of manuscripts and illustrative materials.

—R. C. SMITH, *Chairman pro tem*
F. L. CAMPBELL (absent second meeting)
R. B. FRIEND
J. S. HOUSER
G. M. LIST
W. A. RILEY
S. A. ROHWER
M. A. STEWART (for W. B. Herms)

(The change in JOURNAL format and nomination of officers of the JOURNAL was duly moved, seconded and approved by the Association in regular business session on Friday, December 31, 1937.)

REPORT OF NOMINATING COMMITTEE

The Nominating Committee reported at two meetings, and the following officers and committee members were unanimously elected:

President: J. J. Davis
First Vice President: G. M. List
Vice Presidents:
J. R. Eyer (Pacific Slope Branch)

W. E. Dove (Cotton States Branch)
V. I. Safro (Eastern Branch)
E. L. Chambers (Plant Quarantine and Inspection)
J. M. Robinson (Apiculture)
William E. Blauvelt (Extension)

Executive Committee: Clay Lyle. Term expires 1940

Committee on Common Names of Insects
Claude Wakeland. Term expires 1940
T. E. Snyder. Term expires 1940

Committee on Membership: C. L. Metcalf. Term expires 1940

Publications Committee:
R. R. Parker. Term expires 1942
E. J. Newcomer. Term expires 1942

Joint Committee on Insect Collections:
Franklin Sherman. Term expires 1940

Board of Trustees of Permanent Fund: Arthur Gibson. Term expires 1940

Representative to National Research Council:
P. N. Annand. Term expires July 1, 1941
Z. P. Metcalf (Alternate). Term expires July 1, 1941

Councillor for American Association for the Advancement of Science: James I. Hambleton. Term expires 1939

Trustee for Crop Protection Institute: P. J. Parrott. Term expires 1940

Program Committee: George A. Dean. Term expires 1940

Representatives on Council of Union of American Biological Societies:
S. A. Rohwer. Term expires 1938
Carl J. Drake. Term expires 1938

Representative on Board of Trustees of Tropical Plant Research Foundation: Herbert T. Osborn. Term expires 1938

Committee on Codling Moth:
B. A. Porter. Term expires 1940
C. R. Cutright. Term expires 1940

Committee on Insecticide Terminology: F. Leslie Campbell. Term expires 1942. (C. M. Smith, present Chairman of this Committee, requested that he be relieved of the duties of Chairman, although remaining a member of the Committee. H. F. Dietz is therefore nominated as new Chairman.)

Joint Committee on the Promotion of Official Entomology: George A. Dean. Term expires 1940

Committee on Popular Entomological Education:
R. R. Reppert. Term expires 1940

Committee on Cooperation with Pest Control Operators:
George L. Hockenyos. Term expires 1938
E. A. Black. Term expires 1939
J. J. Davis, Chairman. Term expires 1940

Committee on the Relation of Entomology to Conservation:
A. L. Strand. Term expires 1938
Samuel S. Graham. Term expires 1939
F. C. Bishop, Chairman. Term expires 1940

The Committee reported an error in the expiration date of T. J. Headlee's term as a member of the Executive Committee. This should run through 1938 instead of 1937, as given in last year's list.

—B. A. PORTER, *Chairman*
J. S. HOUSER
C. O. EDDY

SECTION OF APICULTURE

The Section of Apiculture met at 9:30 December 28, in the Travertine Room, Hotel Lincoln, Indianapolis, Ind. Due to illness of E. J. Anderson, Chairman, B. Elwood Montgomery was selected Chairman for this meeting. There were 13 papers on the program. Some were read by title only, due to the absence of the authors.

At the conclusion of the discussions, the nominating committee consisting of E. F. Phillips, G. M. Bently and S. B. Fracker submitted its report. This resulted in the election of the following officers for the ensuing year: J. M. Robinson, Chairman, and W. A. Price, Secretary.

—W. A. PRICE, *Secretary*

SECTION OF PLANT QUARANTINE AND INSPECTION

The meeting of the Section of Plant Quarantine and Inspection of the American Association of Economic Entomologists convened at 10 a.m., December 30 in the Lincoln Room of the Hotel Lincoln at Indianapolis, Ind.

Professor A. G. Ruggles was selected to act as Chairman because of the death of L. H. Worthley, who had been elected to this office at Atlantic City.

The Chairman appointed a joint Committee on Resolutions and Nominations, consisting of E. R. Sasscer, Chairman, L. M. Gates and J. Carl Dawson.

The following resolution was presented and adopted:

"The Section of Plant Quarantine and Inspection of the American Association of Economic Entomologists, has lost by death its beloved member and chairman, Leon Howard Worthley.

"We express our sorrow that the Section and the Association have been deprived of one of their most eminent leaders, one who has conspicuously contributed to the advancement of the field of plant quarantines—that each of us members has lost a loyal and helpful friend—and we extend our sincerest sympathy to his bereaved widow.

"We unanimously recommend to the American Association of Economic Entomologists that a biography of our late member and Chairman be prepared and published in the JOURNAL OF ECONOMIC ENTOMOLOGY, and that a copy of this resolution and the biography be sent to Mrs. Worthley."

The Committee recommended and the section elected, for 1938, E. L. Chambers as Chairman and R. A Sheals as Secretary.

OFFICIAL ROSTER

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

[Organized 1889; Incorporated December 29, 1913]

OFFICERS, 1938

J. J. DAVIS	GEORGE M. LIST	ERNEST N. CORY
Lafayette, Ind.	Fort Collins, Colo.	College Park, Md.
President	*First Vice President*	*Secretary*

Vice Presidents

J. R. EYER, State College, N. M. (Pacific Slope Branch.)
W. E. DOVE, San Antonio, Tex. (Cotton States Branch.)
V. I. SAFRO, New York, N. Y. (Eastern Branch.)
E. L. CHAMBERS, Madison, Wis. (Plant Quarantine and Inspection.)
J. M. ROBINSON, Auburn, Ala. (Apiculture.)
WILLIAM E. BLAUVELT, Ithaca, N. Y. (Extension.)

Branch and Section Secretaries

J. F. LAMIMAN, Davis, Calif. (Pacific Slope Branch.)
O. I. SNAPP, Fort Valley, Ga. (Cotton States Branch.)
H. B. WEISS, Trenton, N. J. (Eastern Branch.)
R. A. SHEALS, Washington, D. C. (Plant Quarantine and Inspection.)
W. A. PRICE, Lexington, Ky. (Apiculture.)
W. C. NETTLES, Clemson College, S. C. (Extension.)

STANDING COMMITTEES

Executive Committee

J. J. DAVIS, Lafayette, Ind., *Chairman, Ex officio.*
ERNEST N. CORY, College Park, Md. *Ex officio.*
T. J. HEADLEE, New Brunswick, N. J. Term expires 1938.
L. S. MCLAINE, Ottawa, Can. Term expires 1938.
A. F. BURGESS, Greenfield, Mass. Term expires 1939.
F. C. BISHOPP, Washington, D. C. Term expires 1939.
CLAY LYLE, State College, Miss. Term expires 1940.

Committee on Common Names of Insects

J. A. HYSLOP, Washington, D. C., *Chairman.* Term expires 1939.
R. B. FRIEND, New Haven, Conn. Term expires 1939.
H. B. HUNGERFORD, Lawrence, Kan. Term expires 1938.
L. M. PEAIRS, Morgantown, W. Va. Term expires 1938.
CLAUDE WAKELAND, Moscow, Idaho. Term expires 1940.
T. E. SNYDER, New Orleans, La. Term expires 1940.

Committee on Membership

A. F. SATTERTHWAIT, Urbana, Ill., *Chairman.* Term expires 1938.
W. P. FLINT, Urbana, Ill. Term expires 1939.
C. L. METCALF, Urbana, Ill. Term expires 1940.

Publication Committee, Journal of Economic Entomology

W. B. HERMS, Berkeley, Calif., *Chairman.* Term expires 1940.
ROGER B. FRIEND, New Haven, Conn. Term expires 1938.
J. S. HOUSER, Wooster, Ohio. Term expires 1938.
H. G. CRAWFORD, Ottawa, Can. Term expires 1939.
ROGER C. SMITH, Manhattan, Kan. Term expires 1939.
S. A. ROHWER, Washington, D.C. Term expires 1940.
F. L. CAMPBELL, Columbus, Ohio. Term expires 1941.
F. L. THOMAS, College Station, Tex. Term expires 1941.
R. R. PARKER, Hamilton, Mont. Term expires 1942.
E. J. NEWCOMER, Yakima, Wash. Term expires 1942.

Joint Committee on Insect Collections

C. F. W. MUESEBECK, Washington, D.C., *Chairman.* Term expires 1939.
W. H. BROWN, Ottawa, Can. Term expires 1938.
E. C. VAN DYKE, Berkeley, Calif. Term expires 1938.
C. P. ALEXANDER, Amherst, Mass. Term expires 1938.
JOSEF KNULL, Columbus, Ohio. Term expires 1939.
T. H. FRISON, Urbana, Ill. Term expires 1939.
FRANKLIN SHERMAN, Clemson College, S. C. Term expires 1940.
R. H. BEAMER, Lawrence, Kansas. Term expires 1940.

Program Committee

W. P. FLINT, Urbana, Ill. *Chairman.* Term expires 1939.
D. L. VAN DINE, Washington, D. C. Term expires 1938.
GEORGE A. DEAN, Manhattan, Kans. Term expires 1940.

Committee on Codling Moth

B. A. PORTER, Washington, D. C., *Chairman.* Term expires 1940.
P. J. PARROTT, Geneva, N. Y. Term expires 1938.
W. A. ROSS, Vineland Station, Ont., Can. Term expires 1938.
R. L. WEBSTER, Pullman, Wash. Term expires 1939.
H. N. WORTHLEY, State College, Pa. Term expires 1939.
C. R. CUTRIGHT, Wooster, Ohio. Term expires 1940

Committee on Insecticide Terminology

HARRY F. DIETZ, Wilmington, Del., *Chairman.* Term expires 1941.
R. H. ROBINSON, Corvallis, Ore. Term expires 1938.
WILLIAM MOORE, New York, N. Y. Term expires 1939.
C. M. SMITH, Washington, D. C. Term expires 1940.
F. LESLIE CAMPBELL, Columbus, Ohio. Term expires 1942.

Joint Committee on the Promotion of Official Entomology

E. F. PHILLIPS, Ithaca, N. Y., *Chairman.* Term expires 1938.
GEORGE A. DEAN, Manhattan, Kans. Term expires 1940.
J. J. DAVIS, Lafayette, Ind. Term expires 1939.

Committee on Popular Entomological Education

J. A. HYSLOP, Washington, D. C., *Chairman.* Term expires 1938.
R. R. REPPERT, College Station, Tex. Term expires 1940.
C. J. DRAKE, Ames, Iowa. Term expires 1939.

Committee on Cooperation with Pest Control Operators

J. J. DAVIS, Lafayette, Ind., *Chairman.* Term expires 1940.
GEORGE L. HOCKENYOS, Springfield, Ill. Term expires 1938.
E. A. BACK, Washington, D. C. Term expires 1939.

Committee on the Relation of Entomology to Conservation

F. C. BISHOPP, Washington, D. C., *Chairman.* Term expires 1940.
SAMUEL S. GRAHAM, Ann Arbor, Mich. Term expires 1939.
A. L. STRAND, Bozeman, Mont. Term expires 1938.

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A. F. BURGESS, Greenfield, Mass. Term expires 1938.
P. J. CHAPMAN, Geneva, N. Y. Term expires 1939.
ARTHUR GIBSON, Ottawa, Can. Term expires 1940.

Trustees for Crop Protection Institute

W. C. O'KANE, Durham, N. H. Term expires 1938.
J. J. DAVIS, Lafayette, Ind. Term expires 1939.
P. J. PARROTT, Geneva, N. Y. Term expires 1940.

REPRESENTATIVES AND COUNCILORS

Representatives on Council of Union of American Biological Societies

S. A. ROHWER, Washington, D. C. Term expires 1938.
C. J. DRAKE, Ames, Iowa. Term expires 1938.

Representative on Board of Trustees of Tropical Plant Research Foundation

HERBERT T. OSBORN, Winter Park, Fla.. Term expires 1938.

Representatives to National Research Council

P. N. ANNAND, Washington, D. C. Term expires 1941.

Z. P. METCALF, West Raleigh, N. C. (Alternate.) Term expires 1941.

Councillors for the American Association for the Advancement of Science

LEONARD HASEMAN, Columbia, Mo. Term expires 1938.

JAMES I. HAMBLETON, Beltsville, Md. Term expires 1939.

JOURNAL OF ECONOMIC ENTOMOLOGY

Editorial Board

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HARRY B. WEISS, Trenton, N. J., *Associate Editor.*

MEMBERS, 1938

** Members who attended 1937 meeting
†† Life Members

Active Members

Aamodt, T. L., University Farm, St. Paul, Minn.**
Abbott, W. S., 23 Kenebee Ave., Takoma Park, Md.
Adair, H. S., Adair's Insect Control Service, Montgomery, Ala.
Adams, J. A., Grinnell College, Grinnell, Iowa.
Ainslee, C. N., 5009 Orleans Ave., Sioux City, Iowa.
Alden, C. H., State Board of Ent., Cornelia, Ga.
Alexander, Chas. P., Massachusetts State College, Amherst, Mass.
Allen, H. W., Box H., Moorestown, N. J.
Allen, Norman, Pee Dee Experiment Station, Florence, S. C.
Allen, Paul B., Jr., Vrandenburg Apts. 211, Wenatchee, Wash.
Allen, R. H., Board of Agr., State House, Boston, Mass.
Allen, Thos. C., Dept. of Ent., University of Wisconsin, Madison, Wis.
Alsterlund, John 205 Floriculture Bldg., Urbana, Ill.
Amos, John M., Dept. of Ent., U. of Del., Newark, Del.**
Anderson, Edwin J., Pennsylvania State College, State College, Pa.
Anderson, L. D., Truck Experiment Station, Norfolk, Va.**
Anderson, O. G., Tobacco By-Products Chemical Corp., Louisville, Ky.
Anderson, William E., Dept. of Agr. & Immigration, Baton Rouge, La.
Anderson, Wm. H., Room 429, U. S. Nat. Museum Washington, D. C.
Andre, Floyd, Science Bldg., Iowa State College, Ames, Iowa.**
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Arant, F. S., Auburn, Ala.
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Arnott, Edward H., Arnott Experminating Co., 247 Massachusetts Ave., Indianapolis, Ind.
Ashworth, John T., Danielson, Conn.
Au, S., Box 3319, Board of Agr., Honolulu, T. H.
Audant, Andre, S.N.P.A., Port au Prince, Haiti.
Avery, Paul C., Mission, Tex.

Babcock, O. G., Box 407, Sonora, Tex.
Back, E. A., B.E.P.Q., Washington, D. C.**
Badertscher, Amos E., 2824 Overland Ave., Baltimore, Md.
Baerg, Wm. J., Fayetteville, Ark.**
Bailey, H. L., Dept. of Agr., Montpelier, Vt.
Bailey, J. L., Box 283, Greenfield, Mass.
Bailey, John W., Richmond University, Richmond, Va.
Bailey, Stanley F., University Farm, Davis, Calif.
Baird, Alfred Briggs, 228 Dundas St. E., Belleville, Ont.
Baker, Arthur C., Laboratory of Entomology, Calzada Tacuba 295, Colonia Anahuac Mexico, D. F.**
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Stellwaag, Dr. Frederich, Geisenheim am Rhine, Germany.

Trouvelot, Bernard, Station Centrale, Route de Sainte Cyr, Versailles, France.
Tyron, H., Queensland Museum, Brisbane, Queensland, Australia.

Wille, Dr. Johannes, Apartado 2791, Lima, Peru.

Yuasa, Hachiro, Doshisha University, Kyoto, Japan.

Zander, Enoch, Landesinstitut für Bienensucht, Erlangen, Germany.

THIRD ANNUAL FLORIDA ENTOMOLOGICAL CONFERENCE

The Third Annual Florida Entomological Conference, sponsored by the Newell Entomological Society, will be held in Gainesville, Florida, March 18–19, 1938. The program for this occasion will be released on March 1. Many national entomological figures will appear before the assemblage. On the night of March 19 the Newell Society will hold its annual banquet. This year the banquet will be in honor of Dr. H. T. Fernald, Professor Emeritus of Massachusettes State College. All entomologists visiting in the state of Florida during the month of March are cordially invited to attend the conference and banquet. If possible they should notify Dr. John T. Creighton of the Department of Entomology and Plant Pathology, University of Florida, Gainesville.

CONSTITUTION

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Article I

Name and Objectives

Section 1. This association shall be known as the American Association of Economic Entomologists.

Section 2. Its objectives shall be: [1] to promote the study and to advance the science of entomology; [2] to publish the JOURNAL OF ECONOMIC ENTOMOLOGY and other entomological publications.

Article II

Branches, Sections and Affiliated Organizations

Section 1. This association may recognize Sections and Branches and may approve the affiliation of societies and organizations which are permanently established and which have been organized for purposes not inconsistent with the aims of this organization and which meet the requirements of its constitution and by-laws. Existing Sections and Branches shall function as heretofore and shall be governed by the agreements under which they were created, unless such agreements are modified or revoked by the Association after conference with the Sections or Branches concerned.

Section 2. Sections shall be limited in scope to matters in which the members concerned are particularly interested. They shall be organized for the purpose of holding meetings or conferences, with or without fixed programs, in order to evolve or to improve methods bearing directly on a better development of the special field in which the group is interested. Any group of not less than 25 members of the Association may petition the Association for the formation of a Section, giving full information of its purposes. All petitions shall be submitted to the Executive Committee for consideration and approval and the Section may be authorized by vote of the Association. Each Section shall be entitled to nominate a Chairman, who shall have general charge of its affairs, and who shall become a Vice-President of the Association after approval by the nominating committee of the Association and election by the Association. Each Section shall elect its own Secretary. No official action except on routine matters shall be made public without approval of the Association.

Section 3. Branches may be authorized on the basis of geographical contiguity, for the purpose of holding meetings, presenting papers, conducting conferences, and stimulating interest in entomology. To secure recognition, Branches must formally petition the Association, be endorsed by the Executive Committee, and be approved by the Association. The petition must set forth the territorial limits of the Branch and indicate clearly the particular purpose for which the Branch is to be formed; that an established unit already exists; that its recognition will be useful to the Association and to entomology; and that it will be permanent and self-supporting. Each Branch shall nominate a Chairman annually, who shall have general charge of the Branch and shall become a Vice-President of the Association after recommendation by the nominating committee of the Association and election by the Association. Each Branch shall elect its own Secretary-Treasurer. All business to be transacted by any recognized Branch of the Association must be in harmony with the policies of the Association, or may be a report protesting the policies of the Association and be presented to the Association through its Executive Committee for consideration and approval, prior to its release. Papers presented to, and discussions within, the Branch by members of the Association and business transacted by the Branch, shall be eligible for submission for inclusion in the publications of the Association.

Section 4. Any organization, having aims and purposes in accord with those of the American Association of Economic Entomologists, may petition this Association for affiliation by making formal application in writing. The application shall indicate the region in which the society or organization operates; shall list all of the members enrolled who are in good standing; and shall indicate that it is self-supporting and organized on a permanent basis. After consideration and approval of the application by the Executive Committee, such organization will be enrolled as an affiliated society after approval by the Association. An affiliated society shall designate one of its members to represent it in the presentation of matters to the Executive Committee or to the Association. It shall submit an annual report of its transactions to the Association.

Article III

Membership

Section 1. The classes of membership shall be Active and Honorary.

Section 2. All persons engaged in work in entomology or allied fields and other persons having suitable training or a deep and sincere interest in entomology may become Active Members at any annual meeting by a two-thirds vote of the members present upon recommendation of the Committee on Membership after a regularly executed application, endorsed by two Active Members and accompanied by required fee, has been filed with the Secretary-Treasurer.

Section 3. Honorary Membership may be conferred on any one who has performed long and distinguished service in the field of entomology. Proposals for Honorary Membership must be made in writing with a supporting statement by two Active Members and such recommendation shall be acted upon by the Committee on Membership and the Association, as is required for Active Membership.

Section 4. Any member who shall pay the Association the sum of $100 shall become a member for life, and members who have retained continuous membership for twenty-five years or more may also become members for life upon payment of $50. Such members shall thereafter be exempted from dues and shall be furnished with the JOURNAL OF ECONOMIC ENTOMOLOGY without further charge.

Section 5. Members in good financial standing have the right to resign. The right to terminate the

membership of any member for due cause is reserved by the Association, but shall not be done except for nonpayment of dues, until opportunity is given such member for defense before the Executive Committee.

Article IV

Officers

Section 1. The officers shall consist of a President, a First Vice-President, and an additional Vice-President for each Section and Branch, each of whom shall be elected annually; a Secretary-Treasurer, who shall be elected for a term of three years; and a Board of Trustees of the Permanent Fund.

Section 2. The President, the retiring President, who shall be a member for two years, and the Secretary-Treasurer of the Association, together with three active members one of whom shall be elected each year for a term of three years, shall constitute the Executive Committee, whose chairman shall be the active President.

Section 3. The Board of Trustees of the Permanent Fund shall consist of the President, the Secretary-Treasurer, and three active members, each of whom shall be elected for a term of three years, so arranged that one member shall be elected annually.

Section 4. No member shall be President for two consecutive terms.

Article V

Funds

Section 1. Funds of the Association shall be of two classes: the general funds and a permanent fund.

Section 2. The general funds of the Association shall be collected, entered, disbursed, and accounted for by the Secretary-Treasurer in such a manner that the financial condition of each activity can be easily determined.

Section 3. The permanent fund shall be established to include all donations, bequests, fees for active membership for life, and such other property or funds as may be added to it. This permanent fund shall be in the custody of the Board of Trustees of the Permanent Fund and all disbursements from this fund shall be over the signature of the Chairman of the Board, who shall be elected annually by the Board. The principal of this fund shall be invested and shall not be expended without the recommendation of the Executive Committee and the approval of the Association at any meeting, notice of such action to be given in the call for said meeting. The interest on this permanent fund in any year may be used to meet necessary expenses of the Association on approval of the Executive Committee; but if not so expended during the year shall be added to the principal.

Article VI

Meetings, Quorum and Voting

Section 1. The annual meeting shall be held at such time and place as may be decided upon by the Association at the previous annual meeting, or by the Executive Committee if a change may become necessary or desirable.

Section 2. Special meetings may be called by order of the Executive Committee and shall be so called on the written request of fifty [50] Active Members.

Section 3. Fifty [50] Active Members shall constitute a quorum for the transaction of business of the Association.

Section 4. Voting and the holding of office shall be limited to Active Members.

Article VII

Amendments

Section 1. All proposed amendments shall be presented to an annual meeting. The President shall then appoint a special committee to consider the amendment which shall report their recommendations at the next annual meeting. The Secretary shall send a copy of the proposed amendment to each Active Member at least thirty days prior to the next annual meeting. A two-thirds vote of the Active Membership present at the meeting shall be required for adoption. Minor changes germane to the subject of the announced amendment may be approved by the Association.

BY-LAWS

Article I

Members

Section 1. All members have equal privileges as to presentation of papers and discussion at the meeting.

Article II

Officers and Their Duties

Section 1. It shall be the duty of the President to preside, and to prepare an address to be delivered at the annual meeting over which he presides. He shall also announce his appointment of the necessary committees at the first session of the annual meeting and shall have and exercise such powers as are reasonably necessary to carry out his official duties, including, with the approval of the Executive Committee, the filling of vacancies in the officers and elected committees; such appointees to serve until the next annual meeting.

Section 2. In the absence of the President, the First Vice-President shall assume the duties of the President.

Section 3. It shall be the duty of the Secretary-Treasurer to act as Business Manager of publications, to make the necessary arrangements for the meetings of the Association, to keep a record of proceedings, and to attend to the general correspondence. He shall collect all moneys due, pay all bills incurred by the Association, submit a report at each annual meeting, and perform such other duties as may be delegated to him. He shall furnish a suitable corporate-surety bond, and his accounts shall be audited annually by a certified public accountant, which audit shall be submitted at the annual meeting. He shall be remunerated in an amount per annum to be determined by the Executive Committee.

Section 4. The Executive Committee shall transact the business of the Association between annual meetings. It shall make recommendations on policies to the Association and shall render a report to the annual meeting. The Executive Committee may receive and approve or reject the reports of the standing or special committees. The committee

shall have a business session at the close of the annual meeting.

Section 5. The Board of Trustees of the Permanent Fund shall have charge of the money or other property placed in the Permanent Fund and shall be authorized to invest it in securities considered legal for trust funds, and shall submit a report of its activities to the Association at each annual meeting. The Trustees shall select a Chairman who shall furnish a suitable corporate-surety bond, and the accounts of the Permanent Fund shall be annually audited by a certified public accountant, which report shall be submitted at the annual meeting.

Section 6. All officers and standing committees, unless otherwise provided for, shall be elected by ballot after recommendations have been made by a nominating committee, provided that nominations of equal validity may be made from the floor.

Section 7. All elected officers of the Association shall assume office after the close of the annual meeting and shall continue to serve for one year unless otherwise provided in the constitution or by other action of the Association.

Section 8. The fiscal year of the Association shall close on November 15, and all financial reports shall be closed as of that date.

Article III

Publications

Section 1. The publications of the Association shall be entrusted to an editor, an associate editor, and a business manager, who shall also be the Secretary-Treasurer of the Association, to be known as the Editorial Board. This board shall be elected annually, except as otherwise specified.

Section 2. The Editor, Associate Editor and Publication Committee shall be elected by the Association upon nomination by the Nominating Committee. The Publication Committee shall consist of ten or more members who shall be elected for terms of two years each, so arranged that half of the members are elected annually. The members of this Committee shall have an advisory relation to the above constituted Editorial Board.

Section 3. The subscription rate of the JOURNAL may be established by vote of the Association at the annual meeting upon recommendation of the Editorial Board.

Article IV

Dues

Section 1. The annual dues of Active Members shall be $2.00, which shall be payable in advance.

Section 2. No annual dues shall be payable from honorary or life members.

Section 3. Annual dues shall not include subscription to the publications of the Association.

Article V

Meetings

Section 1. Special meetings shall be called as provided for in the constitution. Notice of such meetings shall be given by the Secretary-Treasurer by mailing to each active member a formal notification of the time and place of the meeting at least one month before the date fixed in the notice. The notice shall state the reason for such meeting and shall specify the business to be transacted, and no other business shall be transacted.

Article VI

Amendments to By-Laws

Section 1. Changes in these by-laws may be made by a two-thirds vote of the members present at any meeting: Provided, that notice in writing of the proposed amendment shall have been sent to every active member at least one month before the date of the meeting at which it will be considered.

ACTION BY ASSOCIATION IN ANNUAL MEETING

This revision of the constitution was passed unanimously at the final business session of the Fiftieth Annual Meeting in Indianapolis, December 31, 1937. Subsequent to its passage, the following motion was also passed unanimously:

That the revised constitution and by-laws become effective immediately following final adjournment of this annual meeting on December 31, 1937, and that all functions then existing be continued thereunder, including all elected and appointed personnel for their stated terms of office.